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THE

PRACTICAL SUGAR PLANTER;

A COMPLETE ACCOUNT OF THE

CULTIVATION AND MANUFACTURE

OF THE

SUGAR-CANE,

ACCORDING TO THE

LATEST AND MOST IMPROVED PROCESSES.

DESCRIBING AND COMPARING THE DIFFERENT SYSTEMS PURSUED IN THE EAST AND WEST INDIES AND THE STRAITS OF MALACCA, AND THE RELATIVE EXPENSES AND ADVANTAGES ATTENDANT UPON EACH:

BEING THE RESULT OF SIXTEEN YEARS' EXPERIENCE AS A SUGAR PLANTER IN THOSE COUNTRIES.

BY LEONARD WRAY, ESQ.

With Numerous Illustrations.

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THE RIGHT HONOURABLE

THE EARL OF ELGIN AND KINCARDINE,

GOVERNOR-GENERAL OF CANADA, LATE GOVERNOR OF JAMAICA, ETC.

My Lord,

As Governor of Jamaica, at a period when despair had begun to pervade the whole planting community of the West India islands, your Lordship laboured to arouse the drooping energies of the planting body, and to restore that confidence which was fast departing. By addressing yourself to the intelligence of the planters themselves, your Lordship well knew that you were engaging the vigorous minds of really practical men in the great work of improvement; that you were leading their intelligence to exercise itself in the investigation of those causes and effects, which science so readily explains; and that, in pursuing such an investigation, they could not fail to discover a new world of valuable information. In competing for the prizes, which your Lordship (with characteristic penetration and liberality) offered, many of the competitors found it necessary to consult chemical and other authorities, with whose works they had previously been unacquainted; and were thus led on, almost imperceptibly, to recognise facts, of which they had until then been totally ignorant. The perfect realization of your Lordship's anticipations is satisfactorily evidenced in the excellent treatise written by (the late) Mr. Whitehouse on that occasion; for that lamented planter was so sensitive to the injustice that was done him, in the subsequent award of the prize, for which he had competed, that, in an able review of the successful treatise, as well as the others, he exposed their various faults, and demonstrated the correctness of his own views. A discussion of this nature naturally excited the attention of the planters to the points in dispute, and induced an inquiry into the several improvements suggested. Thus a spirit was implanted—a curiosity engendered, which cannot fail to develope itself to the benefit of "the *planting interest.*" It is to your Lordship that this is due; it was yourself who implanted this spirit of energy and inquiry, nurtured it by your fostering care, and protected it by the influence of your rank and station. The planters of the West Indies have not been backward in testifying their respect and gratitude to your Lordship for your valued exertions, which will never be forgotten in those islands.

At the period of which I have spoken, I was in the East Indies; yet I felt that your Lordship's exertions affected beneficially the whole body of sugar planters, and, as a member of that body myself, I have ever since been anxious to offer you my individual acknowledgments.

In presenting these pages to the public, I am afforded an opportunity, the most favourable I may ever have, of gratifying that desire. Permit me then, my Lord, to DEDICATE *this work* to your Lordship: do me the honour to accept it as the humble tribute of my esteem, respect, and gratitude; and allow me to add my truest wishes for your Lordship's long continued health and happiness.

I am, my Lord,

Your Lordship's very humble
and obedient Servant,

LEONARD WRAY.

LONDON, *April* 1848.

PREFACE.

Notwithstanding the vast sums of money, and the important interests involved in the cultivation of the sugar-cane, and the manufacture of its juices into sugar and rum, —notwithstanding the extraordinary changes which, within the last fifteen years, have so vitally affected those interests, and which at the present moment seem to threaten ruin to our sugar growing colonies,—yet we find that from 1830 up to the present time, no *standard work* has appeared to aid and assist the planting body: with the solitary exception of that by Mr. G. R. Porter.

In 1830, that gentleman brought out his book on "the Sugar-cane;" and in 1843 a *second* edition appeared: both of which editions are well known to every sugar planter. But Mr. Porter was himself possessed of no practical knowledge; and although he most truly deserved all the credit which his work has gained him, still it can only be viewed as a compilation, which is excellent in itself, and *has been* useful to many. But is it not remarkable that his should be the only work afforded the English planter, during so long a period, on so important a subject, and at such a critical time; when each succeeding month brings with it an accession of anxiety and dread? It is, indeed, astonishing; and difficult to be accounted for.

As far as small treatises, essays, and pamphlets go, there have been at least some *score* written within the last few years; three-fourths of which were called forth by the prizes offered by the Earl of Elgin, the late Governor of Jamaica. This excellent nobleman addressed himself to the experience and intelligence of the planters themselves, and liberally gave two prizes, of one hundred pounds each, for the best practical treatises; the one on the *cultivation*, and the other on the *manufacture* of the sugar-cane plant. Eight of these I had the honour of receiving as a present from "the Royal Agricultural Society of Jamaica."

Whilst these were being written in the West, I was prevailed on to furnish "the Agri-Horticultural Society of India," with a small treatise applicable to the East Indies; which accordingly appeared in that Society's journal, and gained for me a vote of thanks, and the liberal award of three hundred Company's rupees.

But these small productions* are not of the character demanded by so important and comprehensive a subject. Hence the great want, which is at present felt by the planters in our various colonies, of a complete work, which shall explain the systems pursued in different parts of the world, with their results, and point out, in a clear and practical manner, the most approved modes applicable to each particular locality. It is evident, that to become qualified for such a task, it is necessary, not only to visit the countries whereof it should treat, but also to reside in them, and pursue in each the planter's profession; by which means alone, one can hope to gain that practical experience which will enable him to impart really useful information.

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* Since the above was written, there has appeared a treatise by Dr. Evans, on the art of obtaining sugar from the sugar-cane; which relates to the manufacture of cane juice into sugar.

It is very seldom a planter can be found, who has had these opportunities of collecting information and comparing different systems; indeed, I know but *one*, who has had such opportunities as myself.

Sixteen years' experience as a practical planter in Jamaica, Bengal, and the Straits Settlements, gives me, I think, the necessary qualifications; and should gain for me that attention which, I hope, the succeeding pages will, on perusal, be found to merit.

It will be a source of sincere gratification to me, to know that the result of my experience has been useful to the sugar interests of our colonies; whilst, I am sure, my earnest desire to be of service to my brother planters must, at least, secure me their good will, and attentive consideration to the subject of this work.

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ERRATA.

Page 22.—In 4th paragraph, *for* 20 per cent. may be its maximum, *read* 25 per cent. &c. &c.
— 221.—In foot note, last line, *for* India, *read* Jamaica.
— 316.—In foot note, last line, insert *full*.
— 382.—Head line, *for* recapitulation, *read* reboiling.

THE SUGAR-CANE.

CHAPTER I.

BRIEF GLANCE AT THE HISTORY OF THE SUGAR-CANE.—VARIOUS DESCRIPTIONS AND THEIR QUALITIES.

It is a matter of considerable doubt, whether the sugar-cane plant is a native of America or not. Strong opinions have been given as to the improbability of its being so; whilst, on the other hand, many old writers assert with great confidence the fact. And, indeed, viewing these conflicting accounts dispassionately, we must allow, that, as the plant was found growing in its utmost luxuriance throughout the islands of the Pacific Ocean by our earliest navigators, it requires no great stretch of imagination to believe that it was also growing on the great continents of America long before it was brought there by the Portuguese and Spaniards. It would not be difficult to adduce many arguments in support of this belief: but I am well aware that such a discussion here would be deemed tedious and irrelevant.

The Chinese assert that sugar has been made from the cane, in China, for upwards of 3000 years; and, without disputing with "*the flowery nation*" for a few hundred years more or less, we will at once concede to them their undeniable claim to very great antiquity as sugar manufacturers. But I cannot divest myself of the belief that INDIA—

not China—is in reality, the country from which the sugar-cane FIRST emanated. Whether such be indeed the case or not, we have now no possible means of deciding: and, moreover, it is a question which no way interests the plain matter-of-fact planter; suffice it, therefore, to say, that it is now found growing in almost every tropical country under the sun.

VARIETIES KNOWN, AND THEIR QUALITIES.

From what I have already seen, I do not hesitate to say that an endeavour to describe all the different varieties of cane that are known, would be a wearisome, if not a hopeless, task; from which, it is clear to my mind, that no adequate benefit can be derived. Therefore I will confine myself to a mention of those which have been more prominently brought before me; and amongst them, I think, almost every variety known to the generality of my readers will be found noticed.

In Jamaica, the varieties common are—the Bourbon, the Otaheite, and Batavian canes.

In Bengal,—the yellow and purple ribbon-canes of Otaheite; the Bourbon, or Mauritius; the Singapore (Tibboo Leeut*); the large purple cane of Java; the red cane of Assam; the common, small, hard cane of China; and some ten different kinds of native cane, varying in thickness, from one inch and a half, to half an inch in diameter: the very smallest resembling little riding-switches.

In the Straits settlements of Penang and Province Wellesley, Malacca, and Singapore, the varieties are—the Salangore cane, or, as the Malays term it, Tibboo Cappor; the Tibboo Leeut; the Tibboo Teeloor, or egg cane; the Tibboo Etam, or black cane; the Tibboo Meerah, or red cane; the Tibboo Batavee, or Batavia cane; the Tibboo China, or small China cane; and many others not requiring description.

To give a distinct account of the foregoing canes, I will take them as I have named them, each in succession.

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* Tibboo, or Tubboo, is the Malay name for a sugar cane.

The Bourbon cane.—There does not appear to me to exist any very satisfactory account of the origin of this variety; the opinion generally received is, that it was introduced into the West Indies from the island of *Bourbon*, but came originally from the coast of Malabar, where it was found growing spontaneously. When first discovered, it is stated to have been a small-sized, but soft and juicy cane, which was so much affected by the change of climate, soil, and the cultivation it received in Bourbon, that it increased wonderfully in size and richness of juice; so that it was cultivated in preference to the old species, which at length, it entirely superseded throughout the island.

From my own experience in Jamaica, I can pronounce it a most valuable cane: but I entertain a strong suspicion that it is in reality no other than the Tibboo Leeut of Singapore, (sometimes called the Otaheite cane) somewhat altered by change of soil and climate. I have bestowed considerable attention upon it, and have carefully marked the Tibboo Leeut, growing on entirely different soils, in different situations, and under widely different circumstances, and I can come to no other conclusion than that they are identical.

The Otaheite canes are two; the yellow or straw-coloured, and the purple-striped or ribbon cane.

The former and the Bourbon are so much alike in all respects, and have become so intermixed on West India estates, that it is a matter of great difficulty to distinguish between them: indeed, I have long been of opinion that they are the same variety of cane. If we remember that the Bourbon was taken to that island, then to Martinique, and afterwards spread in course of time throughout the West India islands; that the Otaheite was taken direct from that island to the West Indies, and direct to Calcutta and the Straits Settlements; that the Tibboo Leeut came from Manilla (evidently from Otaheite originally) to the Straits of Malacca:—if we consider these facts, we shall find no cause for astonishment at the very slight difference that exists between them; on the contrary, we must be much struck at the extreme similitude, which even such extraordinary changes have failed to destroy. But let the *three* be collected, and then planted out, under precisely similar circumstances, and I am quite satisfied no man can distinguish the one from the other: at all events, I have no hesitation in owning that I never could; the which has served to convince me that they all came originally from Otaheite.

As I consider them to be the same variety, and as one description serves for the whole, I will therefore treat of them accordingly. With the advantages of a good soil and favourable season, plants of the first year's growth often attain the height of twelve or fourteen feet; measuring six inches in circumference, and with joints eight or nine inches apart. I do not mean to imply that the average size of a field, or of fields, is so large; but that canes may be picked out, from amongst them, fully as large as that. Such plant canes commonly yield (in Jamaica, Bengal, and the Straits) two and a half tons, and not unfrequently three tons, of marketable sugar per acre. Such an amount of produce per acre, is a very common and well-known occurrence; but the general calculation amongst planters is, however, *two tons of dry sugar from each acre* of "plant canes:" that is, canes of the first year's growth. I can see no difference in the yield of this cane, in either Indies; for, in good land, the return is generally as above stated.

Planted at proper seasons, as will be treated of hereafter, they often attain maturity in ten months, and very rarely exceed twelve. Under certain circumstances, it may be expedient to allow them even fourteen months; as in excessively rich land, or a wet season: but, of course, these circumstances come more particularly, under another head; which will be fully discussed in its proper place.

These canes require a generous soil, careful fencing, and attentive management. Many soils which suit other varieties are unfit for the proper development of these; whilst it is generally remarked, that they are more sensible of the injuries committed by the trespassing of cattle, sheep, &c.

during their early growth, than other descriptions. The foliage of the Otaheite is of a pale green, leaves broad and drooping much; and the plant, on arriving at maturity, frequently arrows, or flowers; which renders it, when in extensive fields, exceedingly graceful and ornamental in appearance.

"The purple striped Otaheite" cane is very much like the ribbon cane of Batavia in appearance: but the former has broad purple stripes, on a greenish yellow ground, whereas the latter is of a blood-red, on a transparent straw-coloured ground. It is often called "the Otaheite ribbon cane," in contradistinction to "the ribbon cane of Batavia." Its foliage is of a much darker colour than that of the yellow variety, whilst its leaves droop much less. It is a hardy and estimable description of cane, of large size, soft, juicy, and sweet; and yields sugar in equal quantities, though of a rather dark quality.

The Batavian canes with which I am acquainted are of four descriptions, viz., the yellow violet; the purple violet or Java cane; the "transparent," or ribbon cane; and the Tibboo Batavee, or Batavian cane, of the Straits.

"The yellow violet," so denominated in the West Indies, differs from the Bourbon in being smaller, less juicy, considerably harder, of slower growth, and of a foliage much darker and more erect. When ripe, it is usually of a straw-colour, its skin or rind is thick, and the pith hard; but its juice is rich and abundant. The yellow violet does not require so rich a soil as the Otaheite, but contents itself with that of an inferior description: this renders it of much importance in planting out large tracts of land, some portions of which may be too poor for its superiors. In Jamaica it is usual, in such places, to plant the violet; thus we often see large patches of it flourishing in the midst of a field of the Bourbon. To an unpractised observer, this sight would cause much speculation; as its dark green foliage presents a striking contrast to the pale green of its immediate neighbours, and might lead to the conclusion that those dark green patches were occasioned by some greater degree of fertility and moisture existing in those parts; whereas the contrary is, in fact, the case. The sugar manufactured from this cane, is of a very fine quality ; but considerably less in quantity than the Bourbon. A very common custom of the Jamaica planter is, to mix the yellow violet with Bourbon plant canes, according to proportion ; for the purpose of rectifying the juice of the latter, so that burning and other such vexatious occurrences might not arise in boiling.

" The purple violet," or large black cane of Java, is fully as thick as the Otaheite, with joints varying from three to seven inches apart. In height it is usually about eight or ten feet, with leaves of a lighter green than the " yellow violet." The very upper joints sometimes exhibit faint streaks, becoming imperceptible in the lower joints, which are of the darkest purple colour. Very frequently a white resinous film is seen incrusted on the joints of this cane, which, over the rich purple, presents much the same appearance as that peculiar to the finest bloom raisins. Sometimes this resinous crust lies so thick, that the purple of the cane itself is in some joints scarcely perceptible. When in perfection, it yields a very sweet and rich juice. Being very hard, it is difficult to grind, and affords a comparatively small quantity of juice ; which is sometimes rather troublesome, from the resinous (or gummy) and colouring matter which it contains. It is a very hardy cane, thriving well in poor, dry soils; and in Jamaica it is often planted in the outer rows of the cane fields, to stand the brunt of trespassing cattle ; which, browsing along the roads, or breaking through fences, tear and trample down the canes. To other descriptions of cane, these ravages would be very serious indeed ; but, fortunately, the purple violet is so hardy, that it quickly recovers from such injuries, and springs up again with astonishing rapidity. It was introduced into the West Indies about the same time as the Bourbon, and is still much cultivated. In the Straits the Malays term it Tibboo Etam

(*Etam*, black; *Tibboo*, cane), or black cane, and cultivate it much around their houses, for eating.

"The transparent" or ribbon cane, is much smaller in size than the Otaheite ribbon cane; is of a bright transparent yellow, with a number of blood red streaks or stripes, running the whole length of the stalk, and varying in breadth from a quarter to a full inch; and being very clear withal in its tints, it presents a very pretty appearance. Its leaves are of a green, similar to that of the yellow violet, but more erect. It grows from six to ten feet high, with joints from four to eight inches apart, and four inches in circumference.

"The transparent," is generally planted in light, sandy soils where no other cane will thrive; sometimes it is planted promiscuously with the yellow violet. Although its rind is thick, and general texture hard, yet it yields a good quantity of juice of excellent quality, which is easily converted into fine fair sugar. Planters often grind this cane, also, with Bourbon plants, for the same reason as applies to the yellow violet.

"The Tibboo Batavee," or Batavian cane, is a cane common in the Straits of Malacca, where it is cultivated by the Malays. In appearance it is much like the yellow violet, except in the peculiarity of its colour, which is rather greenish, with a pink shade, in parts; in some of the lower joints, this pink colour is very bright and pretty, whilst in the *upper*, it is more faint and delicate: the joints are seldom more than from three to six inches apart. In height, size, and foliage, it closely resembles the yellow violet; although it differs from it, in being much softer, more juicy, and less hardy in habit. In a rich soil it is prolific and rattoons well,—its juice is rich, clarifies easily, and gives a fine sugar: but on the whole, it is inferior to the Otaheite variety, yet requires an equally rich soil.

A description of cane was sent from the Mauritius to Province Wellesley, Pinang, under the general name of "the Mauritius cane," and I had several opportunities of seeing it growing, when but young. It is very different from other descriptions of cane I have seen from the Mauritius, and it struck me as being an East Indian cane improved by cultivation.

I have seen only three varieties of large canes, on the Continent of India, which are supposed to be peculiar to the country: one is the large red cane of Assam, specimens of which were kindly sent me by Dr. Keith Scott, the hon. East India Company's civil surgeon, at Gowhatty in Assam. This gentleman had established a sugar estate at Gowhatty, and made sugar; so that he had experience of the right sort, which lends to his opinion considerable weight. In writing of these canes, he says:—"This morning I despatched by the Assam Company's tea boat, a couple of red sugar canes for you, requesting the Honorary Secretary of the Company to forward them to you. They are of a description you may not have met with before, very juicy and sweet; the sugar produced from them is of an exceedingly fine grain and good colour: they are moreover strong in growth, and much less apt to fall over than the Otaheite, to which they are fully equal in size, as well as in quantity and quality of juice. I am also preparing for you some "*flowers*" of this cane, in different stages; which I will despatch, when quite dried. I have now (January) canes in flower, which were planted last May!!"

So that the canes in flower, were only eight months old; consequently they could be cut and manufactured in ten months from the day of being planted. I am sorry to say that two months elapsed before I received these fine canes, by which time they were dead and withered up.

Some time afterwards, Dr. Scott again sent me two boxes, with some pieces of the same cane, *growing;* but unfortunately they did not survive the long and roundabout way by which, through unforeseen occurrences, they were sent.

I subsequently had a long and interesting conversation with my kind and excellent friend, when he repeated all he had before written, and added much more, in praise of this red cane,—from all which I have been led to form a very high opinion of it.

In Lower Bengal (near Calcutta), and in the Straits of Malacca, a large red cane abounds, which bears so exact a resemblance to Dr. Scott's Assam cane, that I conceive it to be the same identical variety, somewhat improved in the rich and fertile soil of Assam. It must be remembered that I do not speak positively, as I never had an opportunity of seeing the foliage of the Assam cane.

The red cane of Bengal, is a large and fine cane, much used about Calcutta for sugar manufacture; and I have had brought to me by natives, sugar made from it by themselves (in their own rough and primitive way), which exhibited a grain of immense size, strength, and brilliancy. They, however, say that it is not a good cane for sugar making, as the juice is very dirty, and the sugar always dark coloured. These assertions, however, have no weight with me; for I can easily detect the cause, and know that it can be avoided.

In the first place, the Bengalee cultivator has a plan of tying up the canes of each root closely together, with bands made with twisted cane leaves; so that, as they grow, the resinous substance exuding from the rind, accumulates along the whole length of each cane, turns black, and, together with the excrement of numerous insects, (which harbour and breed, in these snug retreats,) make the cane-stalk quite filthy: add to this, the exclusion of air and light, which are necessary to the perfect elaboration of the juices, and I think we need not be surprised at the juice being dirty and difficult to clarify. In the Straits of Malacca, I have seen them as clean as other canes, tall, erect, and vigorous: but the Chinese say that in grinding, they give out a considerable quantity of colouring matter,—which by the way would be of little consequence, did they clarify their cane juice properly: which they do not.

I still therefore, incline to the opinion, that they are a fine, and under certain circumstances, valuable description of cane. The Malay name is "*Tibboo merah*"—red cane.

The next large canes, are the black and the yellow Nepaul canes, which I obtained from the kingdom of Nepaul: —four plants of each, growing in boxes. They arrived safely, after a series of adventures, in a fine, healthy condition, giving promise of becoming fine canes: but a long and dangerous illness obliged me to go away for change of air, during which time they were destroyed by goats. They were, however, large sized and fine looking canes, fully equal in appearance to the Assam cane,—and my messengers, together with the Nepaulese (in my employ), gave them the very highest character. I regret to say that I never had another opportunity of seeing these varieties again.

As to the small sized canes cultivated in India, they are so numerous, that I cannot attempt a description of them; moreover, they are, in comparison with those which have been, and are to be, noticed, so very wretched, that did I not know them to be cultivated, by the prejudiced native, to an immense extent, I should deem them unworthy of being mentioned in any way: as it is, I shall have to treat at large of them when I come to explain the cultivation of the cane in India.

"The *China cane*" was received into the Botanic Garden of Calcutta, in 1796, direct from China; having been specially ordered by the Bengal Government, at the suggestion of Dr. Roxburgh, who considered it a new species, and named it, *Saccharum Sinense*, or Chinese sugar cane. Writing in 1799, Dr. Roxburgh says, "it has been cultivated with the utmost possible success; many HUNDRED THOUSANDS have been distributed over the country amongst the cultivators of that article." Dr. Royle* writes, "it possessed the advantage of being so hard and solid as to resist the forceps of the white ants and the teeth of the jackal;

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* See Royle, on the Productive Resources of India, p. 92.

two great enemies to the East India sugar plantations. It was found, however, too difficult to express the juice with the Bengal sugar mill: but Dr. Roxburgh was of opinion that this might be obviated by introducing the simple yet powerful mill of the coast of Coromandel. He further describes the cane as bearing drought much better, than the sorts in general cultivation; producing, moreover, a profitable crop, even to the third year; while the common cane of India must be annually renewed. According to the report of Mr. Touchet, the commercial Resident at Radnagore, and of Mr. R. Carden, superintendent of the Hon. Company's Sugar Plantation Farm at Mirzapore Culna, "it not only resists the ravages of the white ant and jackal, but yields about double the produce of the common Bengal cane."

Independently of this testimony, which I know to be most correct, I can state my own experience of them; and I cannot better do so than by giving the account, as I wrote it, at the time (about four years and a half ago). The Chinese cane was supplied me from the Society's Garden, Calcutta, and took upwards of two months coming up by boat; yet it was perfectly fresh and green on its arrival, whilst the other descriptions of cane had all died, or withered away. From the three hundred canes sent me, by cutting them up into pieces of two joints each, I obtained sufficient to plant out a small patch of ground; which this season yielded me so many canes, that by cutting them up as before, I was enabled to plant out about SIX BEGAHS (four acres) of land with them, besides supplying my neighbours with a few. In its nature it is extremely hardy and prolific; for during the last hot season, it remained uninjured in every respect, whilst the others were all either burnt up, or eaten out of the ground by the white ants. As the rains came on, the China canes sprung up wonderfully, many roots having no less than THIRTY shoots; which, by September, had become fine canes, about twelve feet in height, three inches in circumference, and with joints from six to eight inches apart. These were cut in October, and planted out: yet although we had a tolerably severe winter, the cold appeared to have little or no effect in checking their growth; whereas NATIVE CANES, planted at the same time, were ENTIRELY *kept back.* For their extreme hardiness in withstanding heat and cold, white ants, jackals, &c. &c. I myself can vouch; and moreover I consider that it is a variety of cane which deserves the attention of the East India sugar planter. Such was my opinion nearly five years ago, and I have had every reason since that time to be satisfied of its correctness.

A gentleman in Bengal, largely connected with sugar matters, writing to me on this subject, says, "You may remember that I wrote to you some months ago, soliciting information and advice regarding the "*China cane,*" which you gave so good an account of, in the *Agr. Hor. Society's Journal;* I have much pleasure in now giving you the result of my experiment.

"As you advised, I wrote to the Society for five hundred canes, which arrived quite fresh. I then cut them up, allowing only ONE JOINT to each piece, and planting them in lines, four feet asunder each way, delivered them up to the same chances as my Otaheite and native canes were exposed to. The result has been beyond my utmost hopes; and this too, after a season of unusual severity, which has grievously affected my native cane: and as to my OTAHEITE, what with the hot winds, the white ants, the long continued wet weather, and the detestable jackals, I have saved but a very few; whilst nothing seemed to injure or affect the *China cane.* Did you ever know the Otaheite cane-sprouts to be devoured by caterpillars? I forgot to put those depredators in the list of enemies to the Otaheite plant; although they certainly are very formidable ones, as the partial destruction of many of my plants testified. They attacked the plant when only a few inches above the ground, from which many never recovered.

"I understand that INDIGO PLANTS are often quite destroyed in the same way, so perhaps it may not happen again for some years. This hope determines me in trying the

Otaheite cane once more; when if it does not succeed, I shall keep entirely to the China cane: which, by the by, I am now extending, as far as my plants will allow me. I am disgusted with the native cane, and shall soon put them aside altogether."

I think these accounts of the China cane are sufficient to establish the fact of its being a variety well suited to India: although I need not say that it is immeasurably inferior to the Otaheite, wherever that cane can be cultivated successfully. It was introduced into India in 1796, and in 1799 was spreading rapidly all over the country. It is now very common throughout Bengal, although the natives think it a native cane, from its having been so long amongst them. They have given it a native name, which I quite forget. I met it in several places and recognised it at once; yet I never met but one native who knew it to be otherwise than a native cane. Certainly, its neglected cultivation during fifty odd years in India, has caused it to degenerate very much; hence my advice to all persons desirous of trying it, "send to the Society's Garden, in Calcutta, for it."

It is a very small sized cane, being rarely more than one inch, or one and a quarter inch in diameter; but it is sweet, and makes fine, fair sugar. The Chinese assert that it is better adapted for sugar candy making, than any other cane.

In the Straits settlements of Penang and Province Wellesley, Singapore and Malacca,—the principal canes are eight in number. Of these, first and foremost, is "the SALANGORE CANE," by the Malays of Province Wellesley termed "tibboo bittong beraboo" (the powdery bark cane), but by the Malays of Singapore and Malacca, it is named "tibboo cappor" (the chalk cane), from its having sometimes a considerable quantity of a white resinous substance on the stalk. *This is the* FINEST *description of cane in the Straits Settlements, and* PERHAPS IN THE WHOLE WORLD. In Province Wellesley, it is universally cultivated on all the estates, and is only known to those planters as the China cane; from the simple circumstance of the Chinese cultivators in the province having been in the habit of cultivating it for years, before any European embarked in such speculations in those parts.

I have cut as many as five of the larger canes from one stool; each cane from ten to fifteen feet long, without leaves, and seven and a half inches in circumference, (round the *lower* joints): each cane weighed from 17 to 25 lbs. That of 25 lbs. weight, I kept some weeks in my house, and numbers of people saw it; it was thirteen and a half feet long, and two and a half inches in diameter: yet it was not by any means so large a cane as I have seen. The place where I found it growing was a newly cleared piece of jungle land, whereon a Malay had "*squatted*," built a house, planted rice, and some three acres of sugar cane around it.

The cane plants had been stuck in the ground without regard to regularity, and had received no kind of attention; yet I counted twenty-five canes of immense size, growing from many of the stools. This may be considered a solitary instance: but it is by no means the case, as in any fair jungle land, this cane attains an extraordinary size and height; and I dare to affirm, that on any estate in Province Wellesley, canes can be found, in the cane pieces, which will weigh 15 lbs. at least. It is very evident, that the average size, on an estate of five hundred acres, is much under that: and indeed too large a cane is both inconvenient and undesirable for sugar manufacture.

The Salangore cane is remarkable for the quantity of "*cane itch*," (so termed in the West Indies) which is found on that portion of the leaf attached to the cane-stalk. Sometimes touching a growing cane incautiously, I have had my hand covered with it, and thousands penetrating deep into the flesh, caused great irritation and inflammation. The leaves are very broad, and deeply serrated at the edges, with a considerable droop; they are some shades darker in colour than the Otaheite, and have so good a hold on the stalk as very seldom to fall off, when dry, as some canes do, but require to be taken off by hand. They rattoon better than any canes in the Straits; and I have known them to yield forty piculs (a picul is 133⅓ lb.) of granulated, but undrained sugar, per orlong (an orlong is one acre and a third), as third rattoons. From what I have seen, I am disposed to think that in the West Indies, Mauritius and India, they would be found to rattoon better than any other cane.

As "*plant canes*," I have known them to yield, on an average of some acres, sixty-five piculs of granulated sugar per orlong—or 6,500 lb. per acre. And I have frequently been informed, by a French gentleman, in Province Wellesley, that he has in some cases obtained as much as 7,200 lb. of sugar per acre (undrained); from which he has secured 5,800 lb. of shipping sugar, well dried in the sun.

For my own part, I have always reckoned as an average, 3,600 lb. of dry sugar to the acre, as the return this cane will give, on anything like good land, in the Straits, according to the present imperfect mode of expression and manufacture; but considering the surpassing richness of land, in the West India islands, Demerara, and Mauritius, I should not be in any way surprised to find, that it would there give even three tons an acre.

The Salangore cane grows firm and strong; stands upright much better than the Otaheite; gives juice most abundantly, which is sweet and easy of clarification, boils well, and produces a very fine, fair sugar, of a bold and sparkling grain. On the whole, I like this cane better than any other, and would like to have it tried in the West Indies and Mauritius.

It appears to me to be peculiar to the Malayan Peninsula, and is said to have abounded more particularly in the Rajah of Salangore's territory (between Penang and Malacca). A present, being cultivated on some fifteen or twenty large estates in Province Wellesley, Penang, it is of course obtainable in that settlement in large quantities.

The "*tibboo leeut*" (clay cane), sometimes called the Otaheite, I have already described as belonging to that variety.

The "*tibboo teeloor*" (or egg cane) has long been deemed to be the Otaheite cane by the planters of Province Wellesley: but quite erroneously. It is evidently the cane described by Cook and other navigators, as peculiar to the island of Tanne, one of the New Hebrides. (Quoting from memory) he says, "The sugar-canes of this island, we remarked, were much superior to those of Otaheite, being softer, more juicy, cleaner, of a paler, brighter yellow, and altogether much finer and more luxuriant; but this superiority in the sugar-cane is more than counterbalanced by the great inferiority of the bread-fruit, &c., produced in this island, compared to that of Otaheite."

I have seen many accounts of the same tendency: but I had an opportunity of satisfying myself more completely by meeting in Singapore the master of a ship who had several times visited those islands, and was altogether a very sensible and observant man. He said that himself and his officers had taken particular notice of the extremely clean and bright appearance of the *Tannæ* cane, in comparison with that of Otaheite; and that on his arrival at Singapore, his Dābash (a native who supplies the shipping whilst in harbour) had come off to the ship with a basket of fruit, amongst which were some pieces of sugar cane, which they all immediately recognised as the cane of Tannæ, but which the Dābash told them was called in Singapore the egg cane. He further identified the "tibboo leeut" as the genuine Otaheite cane; and said that every man on board his ship could go into any Chinaman's garden and point out to me, without hesitation, the two different canes! I also discovered that this variety was introduced into Manilla many years ago, and from thence found its way to Singapore, where it is extensively cultivated by the Chinese for sale in the markets; as it is in great request for eating. In size it is fully equal to the Otaheite, whilst it is so exceedingly clean and beautiful, that it surpasses all other canes in appearance.

It has many very singular peculiarities, which no one can overlook or forget. Apart from its extreme cleanness and pretty appearance, it is remarkable for the almost entire absence of *cane-itch*,—smoothness of leaf; the curious manner in which it bulges out between the joints (which has obtained for it the name of the egg cane, from the Malays, who say that it bulges out in the form of an egg); the peculiarity of shedding its leaves as they become dry; its delicate structure, which causes it to fall over, and very, very frequently to break short off; and the large size of the eyes or buds (along the stalk), which are unusually developed, and more readily burst forth than in any other cane I know.

It is very prolific, and with the exception of the China cane, I know no other that can be so quickly propagated; as every eye shoots forth most vigorously, and each stool has generally from five to fifteen canes growing from it.

It produces as much (if not more) juice, of rich quality, as any cane growing; which can be converted into fine, fair sugar, of a good, strong, sparkling grain. But with so many points to recommend it, still there are, undeniably, some very serious, and, I fear fatal objections to it, as a cane for the sugar planter. Its tender nature, liability to fall over, break, and thereby be entirely destroyed, could only be obviated by its being planted, perhaps, on lands securely sheltered from wind, and which also are neither too damp nor too rich.

I have often seen such places: for instance, what we term in Jamaica, *bottoms*, or land lying between hills; which bottoms are generally sufficiently rich for this description of cane, without being too much so. But many places could no doubt be found admirably suited, where it would be well protected, and yet have abundance of sun, which it much requires; otherwise its juice is liable to become watery and mucilaginous: whereas, on the contrary, if it has a fair soil and abundance of sunshine, no juice can be cleaner, and none more rich in saccharine matter.

Some experiments are now going on with this cane on two estates; one of which has fifty acres growing, which will soon be ready for the mill. As far as they have yet been tried, they have, notwithstanding their falling and breaking, yielded very fair returns: but the Chinese contracting cultivators do not like them.

I have already described the Batavia, China, red, and one black cane, found in the Straits, and have, consequently, only one more to notice. This, too, is called "Tibboo etam," but also has an affix, distinctive of its particular character. Thus the Malays term it, "Tibboo etam, obat," or "Black medicine cane," from an idea that in certain diseases it is a very sovereign panacea. What these highly esteemed properties are, I have altogether forgotten: but these plants are frequently found growing in the gardens of Malays, that they may be at hand in case of need. It is a small, but clean and pretty cane, of a rich purple colour; which colour it imparts to the hands and lips of those who eat of it: I was surprised to see how it stained our hands and faces; having never seen such a thing before. One other great peculiarity is the beautiful tint of the leaves, which in some (very young) is of a delicate pink, gradually darkening (in those older) to a fine purple, mingling harmoniously with the green ground of the leaves, and altogether forming a most uncommon and highly pleasing foliage.

From what has been said, it must be evident that the Otaheite and Salangore varieties are the two most valuable canes we know of. It will also be seen that there are, nevertheless, others which, in certain localities, and under peculiar circumstances, become of very great importance, and highly deserving of attention. All this will be rendered more striking as I proceed: I shall therefore only add, that the judicious selection of a variety of cane for planting is of immense importance; as it is not more expensive or troublesome to cultivate a superior cane, which will give large and remunerating returns, than it is to cultivate an inferior kind, which will lead only to disappointment and loss. Nor do I think that any estate should have only one description of cane: it is advisable always to have two, or even three; one of which might be cultivated generally.

CHAPTER II.

THE SUGAR CANE PLANT:—INFLUENCE OF SOIL, CLIMATE, AND SEASONS.

THE sugar cane (*Saccharinum officinarum*) classed in botany as being a genus of the *Triandria digynia*, is a gigantic member of the *Gramineæ* tribe; and, in all its characters, is indubitably one of the most important plants afforded us by a bountiful Providence. One of its products, sugar, is so extensively used, and is in every way such a blessing to mankind, that every exertion should be made to supply it to our poorer fellow-creatures at as cheap a rate as possible.

It is used in every possible way: for sweetening and rendering palatable numberless dishes and liquids, and in making syrups which sweeten, thicken, and preserve the vegetable juices that are made use of in medicine. Fruits are boiled in syrup, and kept under the name of preserves, or sent on voyages to all parts of the known world. It is a well-ascertained fact that man can not only exist, but absolutely become stout and healthy, on sugar and water alone. This was evidenced by the crew of a ship bringing home a cargo of sugar: she encountered sundry disasters, which, together with calms, delayed her so long on her voyage, that all her provisions were consumed, and the crew were obliged to have recourse to the sugar on board; this not only sustained the men, but actually quite cured them of the scurvy, which had made sad havoc amongst the crew previous to their being reduced to this, their last and most providential resource: supported by this agreeable aliment, they reached their port in safety.* This is by no means a solitary instance of the antiscorbutic properties of sugar; whilst its nutritious and fattening qualities are abundantly shown on every sugar estate in the world: however, as this admits of no doubt, I need not dwell on so clear a fact. Sugar is also an excellent antiseptic, much more powerful than even sea-salt; whilst, again, it is recommended by Orfila, as an antidote to the poison of verdigris and oxide of copper.

Nor are its admirable qualities appreciated by mankind alone; for the very beasts of the field, the birds of the air, and numerous reptiles and flies, delight in its sweetness and fatten under its influence.

A most absurd and vulgar prejudice once prevailed against the use of sugar in any quantity: it was said to be unwholesome, to breed worms in the stomach, to injure the teeth, to cause nausea, &c. &c.; whereas undoubted experience has demonstrated that its effects are diametrically opposite to all this; as nothing can be more wholesome, more destructive to worms, less injurious to the teeth, or less calculated to produce nausea. Whenever nausea is produced, it invariably arises, not from the sugar, but from the vile trash mixed up with it under the general name of sweetmeats or sugar-plums. Should any one doubt this latter fact, an analysis of these articles, taken from any confectioner's shop, will readily prove it.

As a primary principle, we desire to obtain year after year, from a given quantity of land, the largest possible amount of first quality sugar, at the least possible expenditure of time, labour, and money. Such results can only be hoped for when the canes to be manufactured are brought to the mill in as perfect a state as the cane plant can arrive at, when the manufacturing apparatus is on the most approved principles, and when the process of manufacture is skilfully, scientifically, economically, and cleanly conducted in all its branches.

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* See note by Porter, taken from *La Gazette de Santé*, No. 44, 1785.

We see, then, that success depends on three distinct circumstances operating in unison; failure in one of which will certainly cause a decided loss more or less: perhaps so considerable as to stamp the whole affair as a vain attempt.

The first of these circumstances, therefore, requires that I should shew the peculiar organization of the cane plant, and the conditions under which the saccharine or crystallizable principle is elaborated and secreted in the greatest abundance. The variations indicated by the saccharometer, together with the disappointments continually expressed by planters in regard to cane juice, prove how little this subject is understood by the planting body, and how highly necessary it is for them to attend to so important a consideration.

When we reflect that cane juice has been known to shew twelve degrees* by Beaumè's saccharometer, and yet very frequently arrives in the boiling-house at six degrees only, and very rarely indeed, higher than eight or ten degrees, we must be struck at the enormous loss sustained by the planter.

But to go further, I do not think it has yet been ascertained in any satisfactory manner, what degree of richness cane juice can be brought to by a rational system of cultivation: 20 per cent. may be its maximum; but I am inclined to think not.

What Mr. Crawford says of average cane juice (in Java) yielding 25 per cent. of sugar, is, without question, a most palpable absurdity; as I will show hereafter: besides, I have clearly ascertained (on authority of the best) that 14 per cent. is there considered high; the average being only 10 per cent. However, leaving this point to be discussed hereafter, I believe enough has been said to prove how imperatively an improvement is demanded in our system of cultivation; and I would earnestly desire the attention of the planting body to the remarks I am about to make on the subject.

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* Twelve degrees Beaumè, indicates fully 21 per cent. of pure sugar.

It must be very apparent to every one, the great influence which particular soils, climates, and seasons exercise on the growth and development of so sensitive a plant as the sugar cane; and it necessarily follows, that the more perfect our knowledge of the nature of such influences, the greater assurance have we of the success of our operations.

I will proceed, therefore, to demonstrate the causes which materially affect the growth of the cane, its proper development, and the elaboration of its juices.

To render this more clear, it is requisite that I should glance at the vegetable economy of the plant, its structure, and the mode in which it extracts substances forming sap from the soil, by means of its roots; also, at the manner in which this sap circulates, and is transformed by the action of the leaves and other green parts into nourishment befitting the plant, and the peculiar circumstances under which the saccharine or crystallizable matter is deposited in the cells, in the greatest abundance. In elucidating these points, I wish it to be distinctly understood that I avail myself of the opinions of the most eminent writers on organic chemistry, &c., (such as Liebig, Raspail, and others) with which I entirely agree; as I shall endeavour to abbreviate and simplify them, to suit the character of this work, without making a constant repetition of their names.

Every planter knows that the cane plant is propagated by cuttings from the cane itself; which are usually the few upper joints of the plant nearest the leaves, commonly designated "the cane top." But sometimes the whole cane is cut up in pieces, and planted out; as every part having a perfect eye or bud will spring forth a plant.

The cane-cutting which is used for planting may be either one, two, or more joints of the cane itself, taken from any part of the cane stalk; as each joint possesses one eye or bud. On being planted, these eyes shoot forth; and at the same time a number of roots are thrown out around the whole circle of each joint, which serve to supply the young plants with sustenance until they are sufficiently advanced to throw out roots of their own. (See plate 1, figure 1.)

It appears that, by depriving the cane-cutting of these roots, the young shoots will continue growing for some time, and then die away before they have become strong enough to form roots of their own. For experiment, place some pieces of cane amongst mouldy straw, in a moist and hot place, and in a few days delicate roots will appear in abundance from the joints; cut off these fibres neatly with a penknife when they are about an inch and a half, or two inches long, taking care not to shake or remove the pieces of cane: watch if further roots appear, and if so, cut off the fibres, as before. During this time the buds will have sprung forth and be growing fast: but it will be observed that, in the course of a few days after the roots are removed, the shoots begin gradually to wither away, and will finally die; notwithstanding all the care they may in other respects receive. This goes to show, that, although the pieces of cane which are planted abound in sugar, gluten, mucilage, &c., &c., yet these alone cannot support the young shoots; which also require the absolute presence of roots, to supply, by their peculiar action, that kind of sap which I shall call "ascending sap;" being a watery solution of earthy salts. Now, in the cane, this sap is supplied by the roots emanating from the piece of cane planted, until the young sprouts or shoots become furnished with perfect roots of their own; when the parent piece dies away and gradually decays. (See fig. 2, plate 1.) The sprouting of the eye, therefore, is simultaneous with the formation of roots; and both combined, constitute the effort made by the cane to reproduce itself.

With the formation of a leaf or leaves, a new action commences (it may be termed a transformation of organic substances), by which that watery solution of earthy salts constituting the ascending sap is first transmitted from the roots to the leaves, where it undergoes an elaboration which changes its character. The functions of leaves and other green parts of plants are to absorb carbonic acid, and by the aid of solar

REFERENCE TO PLATE I.—Page 24.

Figure 1.

A, is the cane-top, or cane-cutting, planted.

B, B, B, B, are the young shoots springing from the joints.

C, C, C, C, are the roots, from the joints, supplying nourishment to the plants.

D, D, D, D, are the joints, from which the shoots spring and the roots emanate.

Figure 2.

A, is the cane-top.

B, B, B, B, are the young cane-plants, springing from the joints, D, D, D, D.

C, C, C, C, are the remnants of the old roots shown as C, C, C, C, in Figure 1.

E, E, E, E, are the young roots thrown out by the young cane-plants themselves, and their support independent of the cane-top, A, which now decays.

F, F, F, F, are the young buds, or "eyes," formed on the joints of the young canes, and springing forth into plants.

PLATE I.

(FIG. 1.)

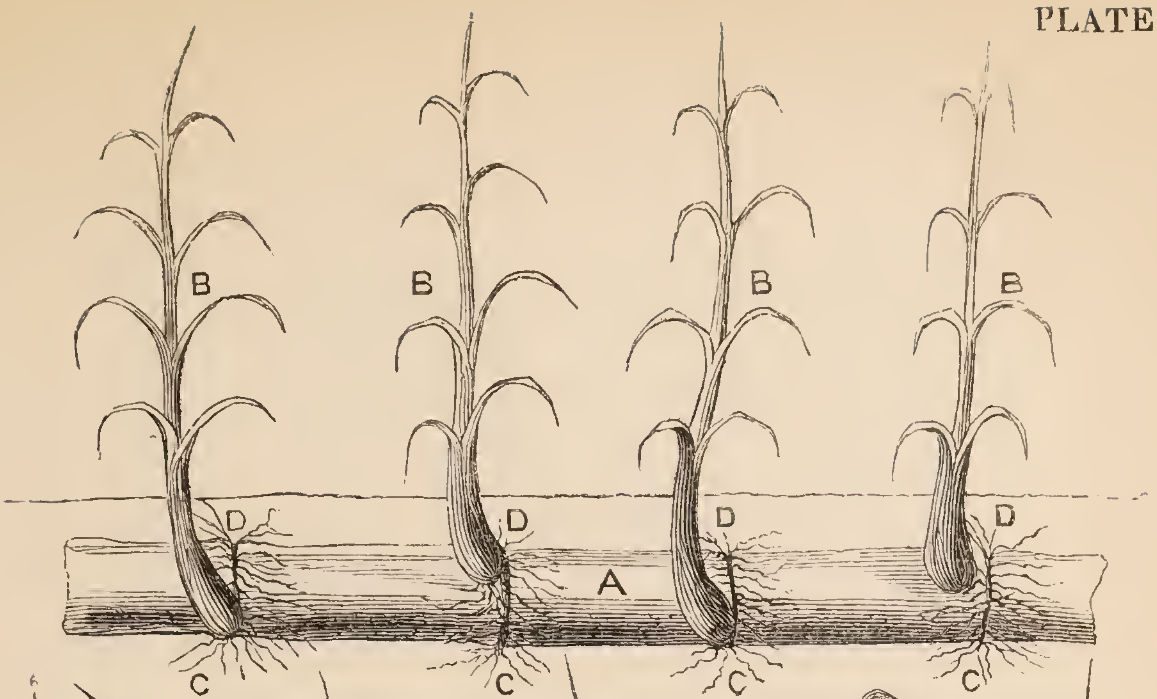
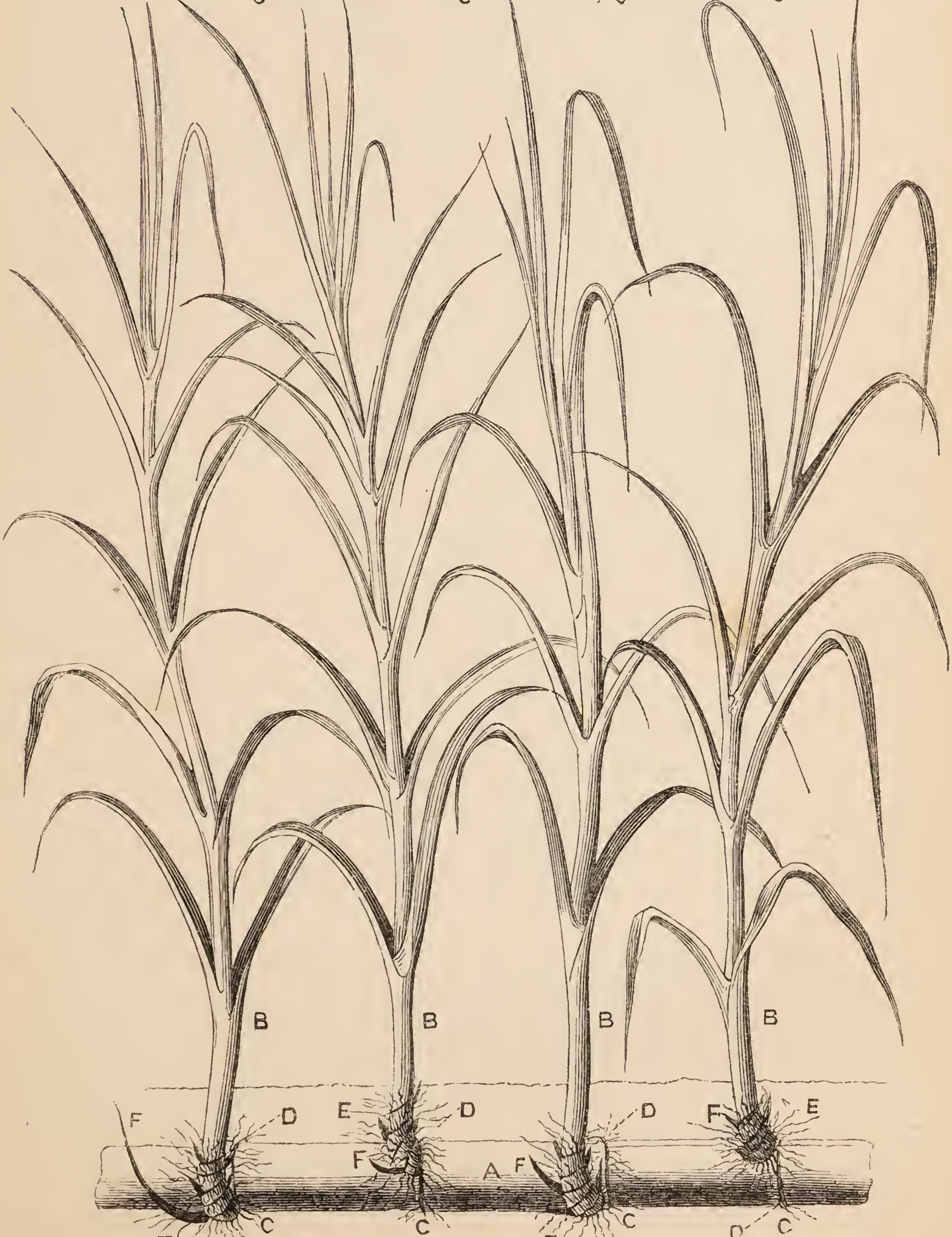


FIG. 2.)



CANE TOP PLANTS THROWING FORTH YOUNG CANE PLANTS.

light and moisture to appropriate its carbon: hence they are called "organs of assimilation." On the first formation of the leaves, these functions commence: they are at first more particularly employed in their own development; afterwards in the formation of woody fibre and other substances necessary for the general purposes of the plant.

Having already mentioned the sap—which I have designated the *as*cending sap in contradistinction to the *de*scending sap,—it is better to discuss the important subject of its circulation and chemical transformations at once, than to defer it longer. It is of course obvious that the roots are immediately connected with the sap vessels, which receive and transmit the sap throughout the whole plant: but this is not all; for the sap vessels are of two classes, viz., the ascending sap vessels, and the descending sap vessels; both communicating with the various organs of assimilation. The circulation is also of two characters: the first, that which is termed cellular, and the second, that denominated vascular. The cellular circulation is that which occurs within the cells, and presents the appearance of two contiguous but unmixed currents running in opposite directions; the vascular circulation, on the other hand, is that which occurs in the vascular network, and exhibits only one continuous current in every part of the tubular vessels. The well-established fact of the power possessed by vegetable membranes, of aspiring and expiring surrounding liquids, explains the means whereby such circulation is kept up. The roots, then, supply a watery solution of earthy salts (or sap *not* tending to organize) to the sap-vessels; through which it ascends, and is diffused even to the very extremity of the leaves; whence it returns (transformed into a sap *tending* to organize) through the descending sap-vessels again to the roots.

In this progress through the plant, the sap is drawn into the different organs in succession; the desirable parts are assimilated, other parts are rejected and pass on; until, at length, those which remain unappropriated, reach the roots, and are voided as excrement.

We here find the roots performing two distinct functions: viz., the collection and transmission of nutriment, and the discharge of excrement. To enable them to perform these important duties, they are found to possess powerful organs of aspiration, by which they suck in those aqueous solutions which constitute the ascending sap; and also other organs, by means of which they expire those substances which, unsuitable or otherwise, have been rejected by the various organs of assimilation through which they have passed.

Most people have remarked the extreme tenacity with which some roots cling to rocks, stones, pieces of gravel, sand, bone, wood, or other substances; and the roots of the cane plant, amongst others, will be found adhering to minute fragments of gravel, sand, wood, &c., &c. (forming soil) in the same manner: yet I may venture to say, that nineteen persons out of twenty do not consider that such adhesion is caused by suction; or in other words by the powerful aspirations of the roots, which alone produces that suction. Such is, in reality, the case, however; and the fact serves to show us, in a forcible manner, the wonderful power exerted by these organs of aspiration. Endued with this faculty, the roots can only extract nutriment from the soil through the medium of water; which renders soluble the constituents whereof the soil is composed. It is obvious how much must depend, in cultivation, not only on the richness of the soil, but on the supply of water which is afforded the plant; as, without an ample allowance of this essential, that richness cannot become soluble in sufficient abundance, and consequently the plant is more or less pinched for want of nutriment. It, however, often occurs that the supply of water is too great: this has a tendency to do injury to the sugar cane, at particular periods; inasmuch as the cane may be required for sugar manufacture when its juices are from this cause too aqueous.

The nature of the soil, also, must greatly affect the quality of the sap; and influence, both in quantity and quality, the sugar produced by the plant: however, this consideration more properly belongs to another branch of the subject.

I have thus briefly described the functions of the roots, and explained that "the ascending sap," or "sap not tending to organize," is transmitted to the leaves, and other parts of the plant, and undergoes an elaboration by which it is transformed into a "sap tending to organize." I will now, therefore, touch on the manner in which this transformation is effected.

Within the tropics, the twenty-four hours may be said to be equally divided into twelve hours of day and twelve hours of night; consequently the leaves, and other green parts of the cane, inhale carbonic acid and exhale oxygen during twelve hours of daylight; whilst during twelve hours of night they inhale oxygen and exhale carbonic acid.

Whilst light is present, carbonic acid is absorbed, and its carbon appropriated: but in the absence of light, the process of assimilation is arrested; because the carbonic acid is no longer decomposed, but is dissolved in the juices which pervade all parts of the plant, and escapes every moment through the leaves, &c. But whilst daylight is so necessary in this respect, it is also equally necessary to the assimilation of hydrogen. Now, hydrogen is received by the plant in the form of water; which, by the aid of light, it decomposes; emitting its oxygen and appropriating its hydrogen. Again, oxygen is necessary to the plant; therefore we find, that whilst the plant is absorbing water by the roots and carbonic acid by the leaves, and by the aid of light, decomposing both, still the oxygen separated from each is not wholly exhaled; but a portion sufficient for its purposes, is retained and appropriated, as are the hydrogen and carbon.

We can imagine how large an amount of oxygen is set free by plants, when we consider the quantity of water and carbonic acid absorbed by their different parts: the roots, for instance, in a moist soil, are constantly transmitting an abundance of watery sap; which water, being decomposed, sets free the oxygen contained. With the carbonic acid absorbed, the same evolution ensues on its decomposition.

The quantity of oxygen thus supplied to the atmosphere is really much greater than the amount derived from it; although the plant absorbs oxygen from the atmosphere at night. The decomposition of carbonic acid is no sooner arrested by want of light, than a true chemical process commences; in consequence of the action of the oxygen in the air upon the organic substances composing the leaves, &c. of the plant.

This brief and simple explanation, I think renders it clear, that it is through the decomposition of water and carbonic acid, that hydrogen, carbon, and oxygen* are obtained by the plant; these serving to constitute the descending sap—"a sap tending to organize."

Attached to each joint of the cane plant, is one leaf, whose peculiar office it is to supply elaborated sap (or sap comprised of earthy salts, nitrogen, &c. blended with carbon, oxygen, and hydrogen) to the various cellular and vascular organs existing in that joint; it therefore follows, as a matter of course, that if the joint be deprived of its leaf before this has completed its functions, considerable loss and injury must accrue to it; inasmuch as the joint is then reduced to a dependence on the nutriment its organs can derive from the already exhausted sap descending from the joint immediately above it. Hence we find that by depriving a joint of its leaf, that joint is never fully developed, but becomes contracted and imperfect. Here we see the necessity of allowing the leaves to remain on the plant until they have performed their office; when the chemical influence of the oxygen of the air produces a change in their colour, and shews that they may be removed with safety.

Planters are very much in the habit of planting canes too closely together; which again leads them on to "trash" those canes too heavily: *id est*, to strip off by hand the leaves of the cane plant, in order to allow air and light to penetrate.

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* This latter also by simple absorption during darkness.

Much intelligence, surely, is not required to convince one that such a practice is erroneous; and, indeed, pregnant with evil consequences. Only fancy rich land planted with canes in rows but three or four feet apart, which grow up so close and tangled that a person cannot walk between the rows without great difficulty, and are so dense that no ray of light can penetrate; then consider the course pursued by the planter: he sends in labourers, once, twice, thrice, with orders to "trash heavily;" or in other words, to strip off, not only every dry leaf, but also every green leaf—except just the few top ones—so that the miserable canes are left in woful plight—naked and wretched in appearance, and rendered quite incapable of perfectly developing several joints in each cane.

Surely our intelligent planters will no longer pursue such an irrational course! If they reflect on the simple though necessary requirements of the plant to be cultivated, they will find that economy of time, labour, and money, and increased quantity and quality of produce, will result from a change of practice.

We often hear of "cane seed;" and latterly a very earnest inquiry was set on foot with a view to decide the question whether the sugar cane is really raised from seed in any part of the world, or not; which terminated, I believe, in establishing the fact of there being no country known wherein the cane is, at present, raised from seed: whatever may have been the case in earlier ages. Bryan Edwards, in his work on the West Indies (vol. ii. book 5th, p. 240), says, "In Abyssinia and other parts of the East, it is easily *raised from the seed.*" (*Vide* Bruce's Travels.) Referring, accordingly, to Bruce's Travels, we find he says (vol. i. c. iv. p. 81)—

"About four miles from this is the village of Nizelet el Arab, consisting of miserable huts. Here begin large plantations of sugar canes, the first we had yet seen. They were loading boats with these to carry to Cairo. I procured from them as many as I desired. The canes are about an inch and a quarter in diameter. * * * * * I was surprised at finding this plant in such a state of perfection so far to the northward. We are now in latitude 29°, and nothing could be more beautiful and perfect than the canes were. I apprehend they were originally a plant of the old continent and transported to the new upon its first discovery; because here in Egypt they grow from seed. I do not know if they do so in Brazil; but they have been, in all times, the produce of Egypt."

Such is Bruce's assertion, which has been so often quoted as proof positive of the cane being raised from seed!

Porter repeats the argument of the cane not being a native of America, as it is there never found to perfect its seed; whilst (on the authority of Bruce) he assigns to the East its original emanation. He writes, "The assumption that it has never been found native in the Colonies of America, seems borne out by the fact that, although it flourishes there, its organs of fructification appear to be without the power of fecundity. A whitish dust, or rather seed, is sometimes produced from the flowers; yet this being sown has never been known to vegetate in the West Indies; while in the East canes may be raised from seed." (Bruce's Travels.)

The constantly recurring idea that canes are raised from seed in Egypt and the East Indies, has kept alive a strong belief that the plant could be much improved by skilful cultivation and care, if this said seed could be obtained by European agriculturists. Hence numerous have been the endeavours, both private and public, which have been made to become possessed of it. The Royal Agricultural Society of Jamaica took up the subject, and exhibited much industry in collecting information; and, for aught I know to the contrary, may still be pursuing the inquiry. As I have often been applied to on the subject, and have instituted many inquiries and experiments in order to satisfy myself and others, I take this opportunity of stating what I have ascertained on the point.

First,—That no variety of sugar cane is known to perfect its seed (or indeed, to produce anything like seed) either in

India, China, the Straits of Malacca, Egypt, or even in the South Sea Islands; as in all those countries the cane is entirely propagated by cuttings.

Secondly,—I have myself tried numerous methods, which I imagined might, by some possibility, cause the plant to perfect its seed. That many of these were fanciful, and perhaps far-fetched, I have no hesitation in owning: under these circumstances, there is no need to make them public, or weary the reader with a long detail. It will be sufficient to give a brief account of two of my experiments, to show the principle on which I proceeded.

Experience and much consideration had quite convinced me that it was entirely useless to hope for any good results from cane flowers, of whatever variety they might be, being brought into contact with cane flowers. I therefore determined to try the *Guinea corn*, or Bajra, and the *Indian corn*, or Boota, with the cane plant.* Now both of these plants perfect their seed; and I ventured to hope that, by planting them together, I might get the flowers of the Guinea corn and Indian corn to impregnate and fructify those of the cane. With this view I carefully manured the soil with such substances as I thought likely to assist the plant; and then, as they grew, cautiously but completely removed the eye or bud of each joint as early as I possibly could, by cutting through the green leaf (without removing it) so as to get at the eye. Allowing a proportionate lapse of time, I planted the two descriptions of corn, beside their appropriate cane plants; and as these grew up together, I brought the flowers into contact with each other, occasionally shaking them smartly, that they might shed their pollen on each other. The Indian corn I deprived of its buds as they appeared, forcing the plant to exert its reproductive powers on the arrow or flower, instead of the ears. My experiments succeeded admirably, so far as concerned the growth of the plants, their flowering together, and the production of seed on the arrow of the Indian corn; but, notwithstanding all my care and attention, I had not the gratification of seeing any seed appear on the cane plants so treated. Microscopic examination showed that no change had been effected as regarded the formation of seed; and the failure of this, my last hope, set the question at rest in my mind.

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* These being of the same tribe, viz. Gramineæ.

I feel satisfied that we shall not succeed in fructifying the flower of the cane; and, moreover, that we shall find no well authenticated instance of the plant having been raised from seed. Indeed, I know of no sufficient authority for the belief that it ever was raised from seed. So far as Bruce is concerned, I can readily understand myself—and imagine I shall have little difficulty in explaining to others—how, in all probability, he was mistaken in the matter. In the first place, I have often known men to whom I have remarked on the cane seeding, say, "But is it really a fact that the cane does not seed? I cannot certainly believe that; for I have seen whole fields of it in blossom, and the flowers hanging down as if quite heavy with seed."

Another told me that he has often passed fields nicely smoothed over, and on inquiring from the natives what was planted therein, has been told, sugar cane: whereas, if pieces of cane had been planted in the field, he would have been able to see them sticking out of the ground; so that it must have been the cane seed which was planted, not pieces of the cane itself. These kind of assertions I have very frequently heard made use of by really intelligent Englishmen, who had resided many years in India; but, like many others, had not been at the trouble of inquiring into matters that were not in their own particular line of business.

A native will sometimes leave a small patch of cane uncut in one corner of his field, until his land is ready for planting; and if asked why he so leaves such cane, he will reply, "My land is not ready for planting yet, so I have left that for seed." Such an answer would be very likely to make a stranger believe that the native was waiting until his land was prepared, and the cane seed perfectly ripe: especially when he sees the canes in flower.

Besides, the natives of India (and I doubt not of Egypt) have a peculiar way of planting cane, and afterwards smoothing over the land, so evenly and completely, that no one unaccustomed to their ways, would imagine pieces of cane were planted there. Then, again, we have everything to allow for on the score of language! What erroneous notions are disseminated to the world through the ignorance of travellers of the languages spoken in the countries which they explore, and afterwards write books about!

Bruce did not speak Egyptian himself; and it is well known what absurd mistakes are made by interpreters. I have myself experienced that very often; and in Egypt, but a few weeks ago, I was particularly struck with this very fact. I had a particularly smart and intelligent dragoman, an Egyptian, who spoke English fluently, as well as Egyptian, Arabic, and Turkish; yet I had great difficulty in obtaining information through him; and I was many times obliged to give up inquiries on many points, as hopeless. I can therefore well fancy how liable Bruce was to suffer in the same way. My own inquiries in Egypt (from both Europeans and natives) directly contradicted the fact as stated by him.

I must own I cannot well explain why planters should be so very anxious to obtain possession of cane seed: surely they can scarcely expect to obtain a finer variety of cane than the Otaheite or Salangore!—a cane that, under favourable circumstances, produces from two to three tons of dry sugar per acre! What more can be desired than this?—What other plant yields so large a return? One needs to see the quantity of canes requisite to give such an amount of sugar, in order to form a just conception of the enormous produce afforded by one acre of land.

For my own part, I see no reason to be dissatisfied with the canes at present cultivated: nor do I think canes produced from seed would possess any advantage over those obtained from cuttings; so that I do not consider the failure of our attempts to discover cane seed, other than a trivial disappointment, of no consequence whatever.

The composition of the soil is a consideration of the utmost importance in establishing a sugar estate. Numerous plantations are daily springing up in various parts of the world, and as ill-grounded notions are often conceived in relation to soil formed by the debris of various rocks, it is desirable that attention be directed to the subject.

Perhaps my readers in one part of the world will be kind enough to recollect that I am writing for the benefit of planters in general: some of whom are placed in very different circumstances to themselves; and, therefore, what is of much importance to one portion may have no immediate interest for the other. I would, however, venture to recommend to the planter a wider range of observation than mere local practice can afford. I well know that, unfortunately, a planter's profession is liable to many changes; which may bring those of one country into engagements in another, where they will find themselves lost in perplexity.

Before I proceed further, it may not be irrelevant to explain, in a few words, how this perplexity arises; and the reasons why I would so strongly impress on my readers who are planters the expediency of studying the peculiarities and systems of other countries.

For my own part, I will honestly confess that, on my arrival in India, I did not give due thought to the extreme difference existing betwixt East and West. I saw a most primitive system of cultivation and manufacture, abounding in everything, shocking to my ideas as a West India planter. I found a perverse and prejudiced race, exhibiting a servile humility, linked with a passive resistance and unwillingness to change, quite disheartening. I found European neighbours so entirely imbued with notions of native inflexibility, that on most points their opinions were worse than useless; whilst, again, on others they were undoubtedly correct, and consequently valuable: but still, by being so biassed in general, I had no confidence to accord them, even when it was deserved.

Time and experience have, of course, shown me how wrong

I was in thus mistrusting altogether; though I can, even at this moment, scarcely imagine how one so circumstanced could act otherwise. Numerous are the cases I have known of West India planters failing in India, and great is the extent to which they have been blamed. It would be ungracious to mention instances; I, therefore, only adduce my own experience, which speaks for itself.

To establish and manage an estate in a new country, a planter requires to be possessed of strong self-reliance, coolness, and untiring patience; and to be ever fertile in expedients, so as to meet all difficulties. But though a planter may have all necessary confidence in himself whilst in the country he is accustomed to, yet send him, say, from the West Indies to establish an estate in the East Indies, and forthwith he becomes perplexed in a hundred different ways: soil, climate, seasons, language, customs, prejudices, &c. all start up to counteract his exertions, and confuse and worry him. He finds himself away some hundreds of miles, perhaps, in the country; far from supplies of every kind, and called on continually to exercise his ingenuity in every conceivable manner.

The present depressed state of our West India colonies is such, that numbers of planters would avail themselves of almost any opportunity of trying their fortunes in the East; where the vastness of the field seems to offer favourable chances to the enterprising. Although India is, in reality, a country very far different from what it is commonly supposed to be—so much so, that eight planters out of ten, who go there, soon wish themselves back again in the West Indies—yet, no doubt, many will, from a variety of circumstances, be tempted to judge for themselves; and either accept engagements or go out on mere speculation.

I cannot, therefore, impress too strongly upon planters the expediency of their informing themselves thoroughly on all subjects relative to the practice of their profession, in all countries to which the manifold chances of a planter's life may lead them.

To return from this digression to our subject. I will proceed to touch on soils of the following rocky formations; as being those to which I have particularly alluded.

Granite* varies very much indeed in its appearance and its constituents; it is commonly, however, composed of felspar, mica, and quartz: but hornblende sometimes assumes the place of mica, and albite that of felspar; although at times they occur together.

Felspar is in colour white or gray: often flesh red; sometimes green, &c. It contains—

	Parts.		Parts.
Silica	64	Alumina	20
Potash	14	Lime	2=100

and sometimes oxide of iron, and water.

Mica is in colour of various shades of gray, passing into green, brown, or black: the lithia mica has usually a peach-blossom red colour. It contains—

	Parts.		Parts.
Silica	47·19	Alumina	33·80
Peroxide of Iron	4·47	Oxide of Manganese	2·58
Lime	0·13	Fluoric Acid	0·29
Potash	8·35	Water	4·07=100·88

Quartz is exceedingly varied in colour: when transparent and colourless, it is commonly called "rock crystal." It contains, when pure, nothing but silica: but sometimes it contains traces of alumina, oxide of iron, and oxide of manganese.

Hornblende, in colour dark bottle-green, contains—

	Parts.		Parts.
Silica	48·83	Lime	10·
Magnesia	13·61	Alumina	7·48
Protoxide of Iron	18·75	Protoxide of Manganese	1·15
Fluoric Acid	0·41	Water	0·50=100·89

Albite varies in colour: it is generally white; but sometimes blue, dingy red, and green, &c. It contains—

	Parts.		Parts.
Silica	70·48	Alumina	18·45
Soda	10·50	Lime	0·55=99·98

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* See Dr. Thompson's "Mineralogy."

By this analysis, we find that soils formed by the decomposition of granite, comprise various constituents highly desirable in a sugar-cane soil; which may be placed as follows: viz., silica, alumina, potash, lime, soda, magnesia, peroxide of iron, protoxide of iron, protoxide of manganese, and fluoric acid. These, with other mineral substances, and an accumulation of vegetable matter in a state of decomposition, serve to constitute a soil of considerable fertility. The disintegrated crystals are constantly, though gradually, decomposing: but it often happens that planters have a prejudice against such land, because they see a large number of these crystals in the soil, and forthwith pronounce it sandy and unsuitable. Many a fine tract of land have I seen lying uncultivated, from no other cause than this unfounded prejudice. A French gentleman in the Straits, showing me his estate, took me to some fields near his house, which he said were the worst of all, and to be abandoned. Not content with this, he stated the canes then growing to be only seven months old, whereas they were eleven; being positively so anxious for the credit of his estate, that he was induced to practise deception, rather than have me form an unfavourable opinion of his property. However, time passed on, and these abused canes were cut and manufactured (being the third crop from that land), when the quantity and excellent quality of the sugar yielded were so satisfactory, that the idea of abandoning the cultivation of these fields could no longer be entertained; therefore, instead of doing so, the Chinaman (cultivating under contract) slightly manured and replanted them. It was then observed that the labour in cleaning, trashing, banking, cutting, and carrying the canes, and manufacturing and curing the produce, was considerably less; whilst the sugar resulting was more, and of far better quality, than that of any other portion of the estate. With all the vivacity of his countrymen, this gentleman thereon became enthusiastic in his praises of this description of soil (decomposed granite), and would fain have had all the lands of his estate of the same quality.

Granite formation is very general in the Straits settlements, and is always found to afford a really good and desirable soil for sugar-cane culture; being always mingled with a large quantity of decayed vegetable matter, furnished by the luxuriant vegetation of ages. In the low, swampy lands of province Wellesley and Malacca, we generally find the debris of granite abounding in the soil, in conjunction with alluvial deposit and vegetable matter; together, forming the richest description of land to be there obtained.

In some parts, however, the soil is very variable indeed; in consequence of the capricious manner in which the beds of decomposed granite occur. Along the Malacca River, this is exhibited to a degree seldom seen elsewhere: a surface-soil of decaying vegetable matter (varying in thickness from one inch to twelve inches) resting on a strata of grayish plastic clay, below which the subsoil appears entirely composed of decomposed felspar of a very pure white; the greyish plastic clay abounding in streaks of a red and yellow colour, and containing a large quantity of disintegrated crystals, as yet undecomposed. This description of land is found in patches here and there, whilst immediately contiguous to it the soil assumes other totally different characters.

Some peculiar descriptions of granite rock resist the action of the elements in a remarkable degree,—as is shown in the case of two obelisks at Rome, which have been erected upwards of three thousand years. Others, again, especially when felspar predominates, quickly crumble away and are destroyed.

On the whole, then, we cannot view the granite formation, as other than favourable to the composition of a good soil, in which argillaceous earth abounds; although its comparative value must, in a great measure, depend on the vegetable and other substances with which it is mixed.

Many descriptions of porphyry and trap rocks occur in the West India Islands, India, and the Straits settlements. I will not, however, attempt to describe them: but confine myself to a brief mention of limestone; red, brown, and yellow clay ironstone; and magnetic and iron pyrites.

In Jamaica, limestone rocks abound, especially in the northern parts; where they are commonly called "honey-combed rocks," from their being worn into various fantastic shapes by the action of the weather. Throughout India, also, they are found very abundantly: where they do not occur in one form, they do in another. Thus in many places the natives dig into the soil, or in the beds of rivers, for a description of concretionary limestone, which is constantly forming, and which they term *kunker.* This kunker is naturally very variable in its constituents; from the indiscriminate manner in which lime, from its strong affinity for acids, enters into combination with the first it may chance to meet.

At a depth of from eighteen to twenty feet in the ground (on the banks of rivers in India), I have often found considerable formations—being lime in combination with silica—of a dirty gray colour; rough, irregular, excessively hard, and giving out abundance of sparks on being struck with a common hammer. Perhaps this ranks rather as a bi-silicate of lime than as a limestone. Limestone consists of lime in combination with carbonic acid and small portions of foreign matter.

As a formation, I know from experience that it exercises a most beneficial influence on the growth of the sugar-cane plant, and the saccharine character of its juice. I well remember a small mountain estate, in the parish of Trelawney, Jamaica, which was so rocky, that in many of the fields planting could only be accomplished by hand (not hoe), as small indication of soil could be seen: yet the roots of the canes insinuated themselves betwixt the stones and rocks, and discovered abundant sources of nutriment of the rarest quality, as the sugar produced by those canes evidenced. I can safely say, that the juice was the cleanest and best

I have seen in any part of the world; and the sugar (made in common open pans) was superior in every respect to any Muscovado I ever saw: that made by the vacuum pan not excepted. Surely this extreme excellence must have been occasioned by this peculiar formation (limestone); and no doubt whatever can exist, that the roots extracted from it this supply of genial nourishment, which exhibited itself so strikingly in the abundance of saccharine matter deposited in the cells of the plant.

Of ironstone, we find in the Straits settlements many varieties; but in Malacca and Singapore the following are most common:—*red hematite*—of a brownish-red colour, in masses, stalactites, and kidney-form balls; powder red, and structure fibrous,—is composed of peroxide of iron, columbic acid, alumina, and water.*

Red clay ironstone and *red siliceous ironstone* are, also, of the same class; and consist of red oxide of iron, more or less mixed with foreign matter.

Brown clay ironstone and *yellow clay ironstone* are of the species termed *hydrous peroxide of iron;* colour, various shades of brown: as yellowish-brown, hair-brown, clove-brown and blackish-brown, streak yellowish-brown. They are found to contain peroxide of iron and water, with very small portions of sesquioxide of manganese and silica: sometimes, also, traces of alumina.

Magnetic pyrites (sulphuret of iron) and *iron or cubic pyrites* (bisulphuret of iron) are very common indeed in the West India Islands and Malacca: the former, which is of a colour intermediate between bronze-yellow and copper-red, is composed of one atom sulphur and one atom iron; the latter is of a characteristic bronze-yellow colour, streak brownish-black, and contains of sulphur two atoms, iron one atom.† These pyrites are very abundant on some lands, and act very prejudicially on vegetation when the lands are not drained properly; as by exposure to the air this substance becomes converted, by the prolonged action of oxygen, into sulphate of iron and sulphuric acid, which remain in solution in the stagnant water that covers the land, rendering it very sour or acid. In seasons of dry weather, evaporation goes on rapidly, and this sour or acid water, percolating through the thick strata of decaying vegetable matter often forming the surface soil, yields to the vegetable matter its oxygen, and thus again resumes its character as iron-pyrites. With every lodgment of water and subsequent absorption these transformations are continually effected, so long as the land remains undrained; but a proper system of drainage altogether arrests these actions, and rescues the crops from the very serious injury sustained thereby.

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* Thompson.

† See Dr. Thompson's work on "Mineralogy, Geology, and Mineral Analysis."

In the Straits of Malacca, land so circumstanced is termed by the Malays *masam* (acid or sour); and they are often sadly perplexed and prejudiced by the partial or total failure of their rice crops, from this cause. But with the Chinese, in the same locality, no inconvenience of the kind is felt, when they pursue their usual system of cultivation. This fact induces a belief that the Chinese choose a sweeter and more fertile description of soil; whereas, in nine cases out of ten, no difference in this respect really exists. For the information of the sugar planter and others in the Straits, I will explain how this change is brought about by the Chinese mode of operation. When a Chinaman cultivates land, he generally acts on the principle that it is more profitable to cultivate one acre thoroughly than two in an imperfect and partial manner; hence we are in the habit of terming their system "garden cultivation," which indeed it is: and a very wise and admirable system it must be allowed to be, which obtains from one acre of land as much as two or three acres commonly yield.

On this principle, therefore, the Chinaman proceeds to choose a patch of land of manageable size, the jungle of which he cuts, allows to dry, and then burns; next he sets to work on the roots and stumps of all trees and bushes remaining in the ground: these he carefully digs out, piles up in heaps, and covers over with earth. The intense heat of a tropical sun quickly dries the heaps sufficiently; when the Chinaman sets them on fire, and attends constantly whilst they are burning, that every portion may be consumed. The ashes and burnt earth resulting are carefully scattered over the land; which is then dug (by hoe) and thoroughly turned up. He next digs a trench, and throws up a bank around the land he has cleared, to drain it; and at the same time to keep out all water from the adjacent lands. Finally, he gives it a second *chankoling* (hoe-digging), and plants out his sugar canes, or whatever else he may please. Thus the first shower of rain saturates the alkalis contained in the ashes (so abundantly spread on the surface of the land), and in solution conveys them to the soil; in which they speedily enter into combination with sulphuric and other acids (existing as before noticed), and form insoluble compounds. Hence we never hear a Chinaman complaining of acidity in land so settled by him. There certainly are lazy Chinese as well as lazy Englishmen, who are sufficiently careless to neglect such precautionary measures: but these form exceptions to the general rule; and they suffer, in common with the Malays, disappointment and frequent loss, from the failure of their crops.

To any one who knows the Malay character, and has seen their slovenly modes of bringing lands under, and keeping them in, cultivation, it is needless to tell how different is their practice from that above detailed. A Malay considers that he has done all that is necessary, if he cuts down and burns the jungle in his own peculiar and partial manner, gives the land a hoe-digging—which, by the way, is indeed but a miserable apology for that important operation—and then plants out his rice or other crops. If he be fortunate enough to obtain a favourable return, he is a proud and happy man—proud of his own singular industry, and happy in contemplating its pleasing results. If, on the contrary, his crops turn out unfavourably after the first and second trials, he is still quite pleased with himself and his exertions: but pronounces the land *masam* (acid), and forthwith removes to another locality; not for an instant allowing a doubt to enter his mind as to the correctness of his mode of cultivation! If they are referred to the Chinese method, and advised to follow it, they will answer "Butool Tuan! Orong cheen puniah uddat, banniah biak, banniah baggoose, tappee banniah susah! Sahya ta buleh buat etoo macham. Orong malayoh, punniah uddat, line macham: deea-orong ta mow kirjah bageetoo susah!"* So that because such a system is *banniah susah* (very difficult), or in other words, because it gives them a little trouble, they persist in their own unthrifty and unprofitable courses; and continue to stigmatize lands as *masam* (acid), which, in reality, are as good and as valuable as any in the country, when drained and cultivated in a rational manner.

Were the mischief arising from these false notions confined to the poor and ignorant Malays, I should not have been so diffuse in my remarks on this subject; but as Europeans (planters and others) are sometimes grievously misled by such assertions of the Malays, I cannot too strongly urge on them the absurdity of trusting to such authority. In the West Indies, proper drainage (and the application of a little lime, if it can be afforded) will entirely relieve the planter from the ill effects of iron-pyrites on their crops.

It often occurs in the Straits settlements, Demerara, Louisiana, and other places, that lands are strongly impregnated with saline matter; which certainly causes the cane to grow most luxuriantly, but affects the juice (and consequently the sugar made from it) very prejudicially. In Province Wellesley, I have known sugar that was quite salt produced the first year from such land; and in the Sunderbunds† it was so very salt, that the sugar estates had to be abandoned. In Demerara, also, infinite trouble and loss result from the same cause. Dr. Ure writes,—

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* "True, sir! the Chinese custom is very good, very excellent, but very difficult! I am not able to do like that. The Malays' custom is different; they don't like such very difficult work!"

† Low land at the mouths of the Ganges, in the Bay of Bengal.

"The following analysis of cane juice, performed by a French chemist, was given me by Mr. Forstall of New Orleans.

"In ten English gallons, of 231 cubic inches each, of juice, marking 8½° Baumé, there are 5¾ ounces, English, of salts, which consist of—

Sulphate of Potash	17·840	grammes	= 15·44 grains each.
Phosphate of Potash	16·028	,,	,,
Chlorure of Potassium	8·355	,,	,,
Acetate of Potash	63·750	,,	,,
Acetate of Lime	36·010	,,	,,
Gelatinous Silica	15·270	,,	,,
	157·253	= 5·57 ounces avoirdupois.	

"To the large proportion of deliquescent saline matter—of which one-half, he says, remains in the sugar—the analyst very properly ascribes the deliquescence and deterioration of the sugar, when kept for some time, or transported. It was probably the juice of the cane grown in the rich alluvial soil of Louisiana; which is more abundant in saline matter than the average soil of our West India Islands. The Demerara cane juice has perhaps the above saline constitution; since it suffers much loss of weight by drainage in the home voyage."

Where salt is present in land—as from the overflowing of the high spring-tides—nothing can be done but making good "bunds" to keep out the salt water, and establishing a good system of drainage. By these means, the soil being well turned up, the excess of saline matter will in a crop or two be carried off by the rains; which will wash the soil and pass off by drainage: and also, in part, by the quantity contained in the cane or other crop grown on the land. In Province Wellesley, this has been the case; and it will always so happen: unless the soil be of that sandy and porous nature which admits of the salt or saltish water soaking up through it during the continuance of the spring tides. When once the cane has imbibed these undesirable salts, they become incorporated in its juice; and then all attempts to get rid of them are quite unavailing. The only course to be pursued with such land is—after bunding and draining it properly—to plant Indian corn, Guinea corn, or Guinea grass on it for two or three years, until the saline matters have become in a degree exhausted; when canes may be planted without fear. I have already said that the soil which I know to have produced the best sugar of any I ever saw, was of a limestone formation; and such I have known (from the estate book) to have rattooned for twenty years! Yet, in consequence of its being a mountainous estate, I doubt much whether it could be profitably cultivated in these times. I will not, therefore, dwell on such soil: but pass on to that known as a "brick-mould."

In the West and East Indies this description of soil abounds, and combines so many advantages, that it may truly be stated as the most desirable soil the planter can have.

"Brick-mould" soil is of various colours, and of course, of variable powers. It is composed of a mixture of sand and clay, in such proportions that air and water can penetrate to some depth with sufficient facility; and it admits of being worked up, by plough or hoe, readily and easily. Vegetable matter and various substances, of course, are mixed up in such soil, and serve to increase its fertility: but a great deal depends on the nature of the clay which is in combination. Clay varies very much in its character, and consequently in its value. It is composed of argillaceous earth (otherwise termed alumina) and silica: very commonly the oxides of iron occur in it also, and impart a red, brownish-red, or blackish-brown colour to the mass; from which it is then denominated a ferruginous clay.

No clay soil can of itself be considered fertile, although it may abound in the elements necessary to fertility; inasmuch as clay is of itself so compact and cohesive as to be entirely closed to the action of air internally: but when in admixture with sand and decayed vegetable matter, in due proportion, it is then in the most favourable condition to benefit by such action. Air and water now penetrate with all desirable freedom; and perform their important parts in an unceasing action on the alkaline constituents, and the decaying vegetable bodies contained in the soil.

Let us here pause for an instant, to inquire into the nature of these actions; the arrest of which causes a soil, abounding in the elements essential to fertility, to become at once barren and unproductive. First, then, we find that atmospheric air—which is composed of carbonic acid gas and oxygen gas, with small portions of ammonia and hydrogen—is required to permeate through the soil in order to afford to it its oxygen; which sets free the alkalis contained in the various constituents of the soil, and keeps up in the vegetable matter or humus a putrefactive fermentation, which causes it to evolve carbonic acid: thus constant supplies of nutriment, in the shape of alkalis in solution and carbonic acid, are being supplied to the roots of the plants growing on that soil. But this is not all; for the carbonic acid gas and ammonia contained in the air, are absorbed by the oxides of iron and alumina, and fixed in the soil; to be presented in a soluble form to the roots of the plants, on the occasion of every shower. Secondly, we perceive that water is absolutely necessary, to dissolve the alkalis and earthy salts contained in the soil, and to furnish them in a state of solution to the plant: but, in addition to these and other important offices, the same water affords to the plant its hydrogen, and a portion of its oxygen; to enable it to effect certain chemical transformations: as treated of at page 27.

Air and water, then, must have free access to soils; otherwise they are barren. Where a due quantity of sand is in combination with clay, no obstacle exists to their action; and when the clays are rich, the sand siliceous, and vegetable matter abundant, the very best soil is presented to us for all agricultural purposes. Its property of retaining moisture, even in the hottest season, is very remarkable; whilst in heavy rains the water drains off very quickly wherever drains exist: thus, under proper management, an excess of water is never retained in the soil; nor does it ever become destitute of moisture. It is easily broken up by the plough or hoe, forming comparatively light work for the cattle and labourers on an estate; and it always yields a more grateful return for the ploughings or "working up" which it receives, than any other description of soil. Brick-mould, therefore, is deservedly esteemed and sought after by all planters; as it not only gives good and abundant returns during the first and second years, but still continues rattooning for many years, advantageously.

I have known many estates to have fine level fields of a rich clay soil, most readily convertible into an excellent brick-mould, by merely carting to it a proper proportion of sand, which also abounded on the properties; yet from neglect, want of information, or other causes, these fields were suffered to remain unimproved in this respect. The lands of a friend of my own, in the Straits settlements, are at this moment in this condition; and although he is striving to the best of his ability to afford them the requisite quantity of sand, yet his cattle are so weakly, and his means so contracted, that I fear a very considerable time will elapse ere his fields can receive anything like the quantity their nature demands.

I must not omit to mention a particular kind of soil which is found in the parish of Trelawney, Jamaica, and is very valuable for sugar cane cultivation. It is of a chocolate colour; varying, however, to a red of different shades of brightness, and has a very glossy or sparkling appearance when first ploughed up: when wet, it soils the hands as would paint.

Bryan Edwards, Porter, and others, make mention of this soil; but I have never known any explanation given as to its origin. I have had a great deal to do with it in the West Indies, and have seen abundance of it in Malacca, and am inclined to pronounce it, as consisting of that micaceous variety of specular iron ore,[*] termed sometimes "iron-froth;" largely combined with lime, in various forms, and other matters.

In Trelawney, limestone formation prevails generally wherever this chocolate-coloured soil is found; and it is but reasonable to suppose that the large quantity of lime dissolved and carried in solution to the soil by the action of the weather, must serve to neutralize any excess of acidity caused by the presence of the mineral oxides. On the whole, it forms a fine friable mould, is easily worked up, is retentive of moisture, and bears excellent crops of canes, which rattoon well, and produce abundance of fair, well-grained sugar.

The oxides of iron and alumina abounding must tend to render such soil fertile, by the large quantity of ammonia which it absorbs from the atmosphere, fixes in the soil, and yields in solution (on the occasion of every fall of rain)[†] to the roots of plants.

The Climate most congenial to the sugar-cane plant is of a warm and moist character, with moderate intervals of hot dry weather, attempered by the refreshing sea-breezes. It has always been found to grow most luxuriantly on islands, and along the sea coasts of mainland; which leads us to conclude that the saline particles borne on the sea-breeze exercise a powerful effect on the growth of the plant. The

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[*] Iron-froth (Eisenrahm) is composed of scaly friable parts which soil strongly: colour between cherry and brownish-red; very soft. (See Dr. Thompson's Mineralogy, Geology, and Mineral Analysis, vol. i. p. 435.) There is a brown scaly powder, which occurs occasionally among primary rocks, and which hitherto has been referred to chlorite, but it is undoubtedly a variety of mica: its constituents are—

Silica	48·166	Magnesia	2·916
Alumina	16·851	Lime	2·675
Peroxide of iron	19·100	Water	2·350
Potash	6·558		98·616

(See Ditto, vol. i. p. 362.

[†] See Liebig's Organic Chemistry, p. 89.

influence of the sea-breeze, however, is exerted in many ways: as by imparting moisture to the soil, even in the hottest weather and driest season; by supplying to it the major portion of the saline matter borne inland; and by affording to the leaves of the canes matter for assimilation: add to which, the abundant dew; which it decidedly affects.

Within the tropics, the cane attains its greatest perfection; cold, to any degree, does not suit its growth or development: hence it cannot be cultivated with success in Europe, although it has often been attempted in Spain and other places.

In Louisiana, the frost often sets in before the planters can get in their crops; and so affects the cane that its juice can no longer be induced to crystallize, unless, indeed, the canes can be cut and manufactured before a thaw occurs.

This is occasioned by the fluid contents of the various cells or organs bursting (from excessive cold) their bounds, and becoming intermingled the one with the other: that is, the saccharine with the nitrogenized principles. Now, whilst the frost continues, the lowness of the temperature prevents the possibility of fermentation; but should a thaw intervene, the temperature of the air is raised sufficiently high to permit a viscous fermentation taking place, which altogether prevents the crystallization of the juice, if afterwards concentrated.

If, after a sharp frost, a thaw or period of comparatively warm weather occurs, of sufficient duration, this viscous fermentation is continued until all the sugar contained in the juice is decomposed, and the commingled fluids have resolved themselves into "a viscid mucilaginous matter," possessing neither sweetness nor acidity. This will occur to the juice of the cane yet uncut: but it also happens to expressed juice under other and singular circumstances; one instance of which, it may not be out of place to mention, as, in both cases, the substances tending to organize become organized, though by courses very different from each other.

"Vauquelin, on examining the juice of the sugar-cane—

which, before being sent from Martinique, had been heated to 212° in closed flasks, in order to absorb the oxygen of the air contained in the flasks—found that it had become changed, during the voyage to France, into a viscid mucilaginous matter, which was with difficulty got out of the flasks. It was insoluble in alcohol. When treated with sulphuric acid, it yielded no grape sugar; and nitric acid changed it into oxalic acid, without any trace of mucic acid. The sugar had become a texture. The substance tending to organize had become organized." *

In the upper districts of India, frost often does great injury to the cane crops; but the manner in which the mischief is effected, is not at all understood by either natives or Europeans. The cane is in every respect a tropical plant, and requires that strong light and heat which are to be found continually in a tropical climate alone.

The influence of *seasons* is a very important subject, to which I must beg leave particularly to direct the attention of the planter. In the first place, I must divide the subject into two parts, in order to treat of the great continent of India separately; as its seasons are entirely different from those of the West India Islands, Mauritius, and the Straits Settlements.

The seasons of the West Indies, Mauritius, Ceylon, and the settlements in the Straits of Malacca are very similar; and indeed the climate and seasons may both be said to be exceedingly alike, as far as regards average heat, equable temperature, duration of rains, &c.: but there are variations arising from difference in local position, which will be particularly stated under their own proper heads.

In the colonies just named, there cannot be said to be any cold season; but they all have distinct periods of hot, dry, and rainy weather more or less marked, and slightly varying in the months during which each occur. In the West Indies these periods are well defined and pretty regular, and the planters commonly choose the spring and the fall as the most eligible times for planting out their fields in canes; but on some estates canes are planted and manufactured all the year round.

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* See Raspail's Organic Chemistry, p. 329.

I may here remark, that I am well aware that, in fifteen cases out of twenty, a managing planter of a West Indian estate is not allowed the free exercise of his own judgment, but is forced to act according to the directions he receives from the agent or planting attorney (as he is termed) of the estate. From this cause, it is not always just to impute blame to the resident manager (or overseer, as he is termed, in Jamaica) for the errors of system, and ill success of the estate nominally under his management: nor can we altogether wonder that a managing planter brooks such a state of dependence, and hesitates, by a show of independence, to risk his livelihood (perhaps that of his family also), and at the same time make an enemy for life of the planting attorney: which very often would result. That such a state of things should exist is much to be deplored; as it is evident, that numerous evils must arise from such a denial of confidence on the part of the planting agent, and feeling of insecurity on that of the resident manager. These, however, are matters more properly belonging to another part of my subject; and I only introduce the mention of them here, that I may be spared the ungracious task of noticing the numerous errors committed on West Indian estates, in regard to seasons.

One of the greatest causes of mischief and injury on sugar estates, is the use of dried cane-trash or magass for fuel, instead of wood or coal. To keep up a supply of this most expensive fuel, what sacrifices are not made!—what delays, what trouble and anxiety does it not occasion! and how unsatisfactorily, or rather how ruinously, does it not act, in regard to the interests and well-being of an estate! It does indeed disarrange the whole system of plantership, and is of itself sufficient to disconcert plans which, in other respects, have been well conceived, and ably carried out. Need I here explain how this happens, and how it affects the particular subject now under notice? I think not. A more suitable place for such an explanation will shortly present itself. I will therefore merely remark, that provided with an abundant and sure supply of good fuel, such as coal or wood, the planter would avail himself to the utmost of the advantages attendant on choice of time and season, for planting canes and manufacturing his produce. No cloudy weather or drizzling rain would then deter him from cutting canes; on the contrary, every reason would urge him to do so: he would strain every nerve to get his ripe canes cut and manufactured before heavy rains came on to render their juice watery; and at the same time to procure tops to plant out during such seasonable weather for planting.

Sunshine or cloudy, fair or showery, it matters not. Certain fields of fine canes require cutting; they are cut: other fields require planting, and the weather is favourable; they are planted. No anxiety can be entertained,—no risk is run; for a bountiful supply of coal (or wood) is on hand, which ensures a certain and rapid manufacture of the juice. Without such fuel, the proper seasons for planting and manufacture can only be partially availed of.

In the West Indies and the Straits Settlements, the sugar cane always shows a great desire to "arrow" or flower during the months of January, February, and March; so much so, that I have frequently seen rattoons of only seven months old arrowing freely. From December to July is decidedly the best season of the year for manufacturing; and from August to end of November may be called the rainy months, or the months during which rain may usually be expected: but in the Straits the seasons are sometimes very capricious.

As the cane approaches maturity, two or three months of hot and moderately dry weather brings it to its highest degree of sweetness, and fits it to yield an abundant return of fine quality sugar: but a slight shower at long intervals is far from being injurious to the juice; on the contrary, it serves to maintain the vigour of the plant, without weakening its juices. Such is the weather a planter always rejoices in for "working off" his crop.

The seasons in India may be divided into the cold, hot, and rainy; each in extreme, as far as the cane is concerned, and consequently as trying to the plant as can well be imagined.

I have planted fields of native cane during the month of December (when in Upper India it is very cold), and the plants did not appear above ground until the weather became warm, in the middle of February! Finding no appearance of vegetation for so long a period, I was thinking of replanting the land, but was told by a neighbour that if I waited until the warm weather set in, I should see the canes I had already planted spring up in a very satisfactory manner; as it was well known that native cane would not vegetate when planted during the cold season. This I have always found to be the case. The Otaheite and Chinese canes are not so affected, although their growth is much impeded. Canes planted during the early part of October attain a tolerable growth by December, when the cold checks them completely; until the warmth of February and a light shower infuse new life into them, and bring forth numerous vigorous shoots. The "hot winds" usually set in in the early part of April,* and continue until the middle of June; scorching and burning up the plants, which are only saved by the rains that then commence. The rapidity of their growth is then truly wonderful: in four months only, fine fields of tall and luxuriant canes have sprung up, where previously all was dry and parched! The change is indeed astonishing.

If it be in a part of the country where frost does not occur, it will sometimes be advantageous to allow the canes to continue in the ground until February; when their juice will be in a richer state than it can be immediately after the rains.

But if frosts are to be feared, it is better to plant at a good distance apart; and, by keeping the plants free from dead leaves, allow air, light, and heat to circulate freely between them, so that they may be cut and manufactured in November.

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* Often in March.

During the rainy season, and whenever thunder-storms occur, canes must receive a very considerable and beneficial impetus, from the electricity which their leaves attract from the overcharged atmosphere; and although we cannot know how it acts, yet no one now can refuse credence to the fact of its wonderful influence on vegetation. Independent of this, however, we are assured of the quantities of ammonia and carbonic acid existing in the atmosphere of a tropical country; both of which are conveyed to the soil by the rains which fall, and serve to renovate and fertilize it. This ammonia exists in the atmosphere of tropical countries in much greater quantities than in that of Europe; in consequence of the putrefactive process being so continual, and so much more rapid than in cold or temperate climates. India, besides 200,000,000 of human beings, teems with myriads of birds, beasts, and fishes; all more or less yielding ammonia to the atmosphere both during life and after death: we can therefore imagine how it must abound. The native cultivators well know the benefit land derives from being often ploughed and worked up during the rainy season; but of course, they do not know the manner in which this renovation takes place: certain it is, that there can be no country in the world where less manure is used, or where the land is so completely stripped —so hardly pressed; yet, by the practice of frequent ploughings, it continues year after year to yield moderate crops. To what is this due? Is it not to atmospheric influence? Most assuredly it is. Whilst I would wish to impress this fact on the planter, I would at the same time point out to him, that although the principle is in part correct, it is on the other hand, in part, stupidly wrong; inasmuch as no* long cultivated land can produce the crops it should, merely aid of atmospheric influence: it must have returned to it as manure a portion of those constituents of which it has been deprived by cropping. The Chinese system of making land produce its utmost, and keeping it up to that standard, is the correct and strictly true principle. What is termed in the Straits, "forcing a soil to exhaustion," is an ignorant and eminently absurd expression, which has no meaning; for if a soil will produce by good management, (say) two tons of sugar, for twenty years in succession, it certainly will continue to do so *ad infinitum:* provided the same good management be exhibited. A bountiful Providence has ordained the seasons to perform their appointed parts, and we shall always receive their aid; but we must not neglect to apply our own labour and skill in furtherance of nature's operations.

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* As a general rule.

CHAPTER III.

MODES OF CULTURE, COMPRISING PLOUGHING, PLANTING, MOULDING, WEEDING, BANKING, TRASHING, &C., IN THE WEST INDIES, EAST INDIES, AND SETTLEMENTS IN THE STRAITS OF MALACCA; AND THE MOST SUITABLE LABOURERS.

It is necessary to treat of the practice and requirements of the three countries, separately; as they differ so much from one another; and as the various operations will be more clearly understood when so arranged.

The West India Islands first engage attention. And I would remark, that although I have a fair general knowledge of the systems pursued in all those colonies, yet my own actual experience amongst them is confined to Jamaica; my observations, therefore, apply more particularly to that island: although, I doubt not, that they will be perfectly understood in the others likewise. Demerara is so differently circumstanced to the islands, that I shall allude to that colony apart from the rest.

Entering on the subject of Jamaica plantership, I feel fully alive to the peculiar nature of the task before me; and am desirous of disclaiming all intention of giving offence: but the whole system is such an entangled mass of mischievous practices (encouraged and supported by self-interest,—old custom,—obstinacy,—and deeply-rooted prejudices), that it is no easy or agreeable undertaking to expose any part of it; for no sooner is the exposure of one error effected, than straightway numerous others are brought to light, each as glaring as the first, and demanding a mention likewise. Thus an impartial and candid review of the subject, is certain to give offence (more or less) to some of the many parties interested. I cannot, however, hope to render intelligible, to absent proprietors and mortgagees, the causes which militate against the well-doing of their West India estates, unless I write plainly, and without reference to individual prejudices and interests. This I find myself obliged to do, in order to offer my observations and experience in as useful a form as possible.

With these brief remarks, I will now proceed to observe, that Jamaica estates must be divided into two classes: viz., those whereon the plough can be used; and those whereon the hoe only can be rendered available. Need I say, that for the former, there is hope; whilst for the latter, there does not appear to be the smallest, under existing circumstances. But have planters availed themselves of the *plough* to the fullest extent? Do we find animal substituted for human labour, as much as is possible? and skilfully contrived and well adapted implements, for the primitive and inefficient hoe?

No, we see nothing of the kind: on the contrary, we find the hoe still in general use, and human labour loudly called for. We find, that where the plough has been tried, in nine cases out of ten, it was unwillingly; and consequently without due attention being paid to considerations of primary importance: much less to minor details. I have, myself, seen a dozen cattle taken out of a guinea-grass pasture, all puffed and bloated out with rich green grass, and at once put to work in a heavy iron plough; without any training, or preparatory course of feeding. I have seen such cattle fall exhausted to the ground in twenty minutes' time, with their tongues lolling out of their mouths, and two drivers lashing them with whips, beating them over the head with heavy sticks, and torturing them in various ways to oblige them to rise and perform work for which they had not been prepared! Can anything be conceived more cruel and absurd than this? Only imagine a steer, puffed out on green and watery grass, being harnessed to a plough, and expected to work through the heat of a tropical sun!—to plough up, perhaps, heavy clay soils, during several hours of the day; when really the poor beast is not in a condition to carry his own weight (alone) over the same land, for one hour. Or, let us vary the idea, and picture to ourselves twelve wretchedly lean and miserably weak cattle put to the same work; whilst the dreadful whip keeps up one incessant round of laceration, to urge the hapless animals to perform that which, in their weak and starved condition, they are quite unequal to! Is this one whit less cruel and absurd? But is this all, that we have to complain of on this point? Very far from it. I have seen cattle trying to work in collars (purposely made and sent out from England) so large, that it was quite possible for the cattle to walk through them!—things that, had I not seen, I could not have credited it were possible any man could have had made. Surely, if a proprietor or agent in England wishes to send English-made collars to his estates in the West Indies, common sense would dictate that he should first try them on a middle-sized steer in England, to satisfy himself that they were of the right size; instead of sending out articles more suitable for full-sized elephants.

Again, I have seen cattle working with "yokes" so heavy, that it was as much as one man could do to lift one of them up: whereas nothing of the kind was necessary; for yokes of one quarter the weight would have been quite strong enough for all purposes.

These little circumstances may seem very trivial, but indeed they are not so: they serve to swell the number of reasons why Jamaica estates do not pay, and account for the heavy losses sustained in the numerous cattle that die off: or rather, that are ignorantly killed, every year! Is it not to be expected that cattle so abused will die? Is it not, indeed, a matter of surprise, that any of them survive such shocking treatment? It really is: and when we consider that good young oxen, or steers, cost in Jamaica from 10*l.* to 16*l.* sterling each, we cannot fail to perceive that every possible reason is in favour of a proper selection and management of cattle; in order to obtain from them the greatest possible amount of work in the shortest possible time, and at the least possible expense and risk. But this is by no means the plan pursued in Jamaica: on many estates it would not be tolerated by the attorney; whilst on others the overseers are too prejudiced, or too indifferent, to attempt an alteration. On almost every estate in the island, the cattle may be seen lying at nights (all the year round) in open and exposed cattle-pens, often knee deep in muck and mire: at one season of the year bloated with green grass, at another half starved, miserable, and swarming with "ticks;" hard worked by day, and wretchedly fed at nights. On no estate have I ever seen good, clean, well-covered-in stalls, in which a steer might be tied up and fed! Neither have I ever seen guinea-grass hay made and stacked, for the working cattle of an estate; that they might become firm in flesh, and capable of great and long continued exertion! Far from all this, I have generally remarked a total disregard for their preservation, amounting to a shameful sacrifice of property: and that in many cases it is wilful, I am quite convinced.

Amongst the many, I will instance a property I was once intimately acquainted with, on the north side of Jamaica, of about 750 acres, and then making 150 hogsheads (of 1,800 lbs. each) of sugar, and 7,500 gallons of rum, which, I think, may well astonish any one, unacquainted with the evil doings of planting agents.

This property had 250 head of horned cattle, worth as nearly as possible 8*l.* a head = 2000*l.* sterling; about 40 mules, value about 20*l.* each = 800*l.*: in all 2,800*l.* sterling, in cattle alone—which one would be apt to suppose an enormous sum; yet this estate was every year supplied with fresh cattle to supply losses by death! This surely was bad enough: but what will be said when I assert that those yearly supplies were not purchases made in the best and cheapest market; which would ensure to the proprietor efficient working animals at the most moderate rate. Nothing of the sort. The agent (or planting attorney, as he is termed) of the estate, would order the manager to go to a particular "breeding pen" in St. Ann's, or St. Elizabeth's, and make choice of a certain number of cattle; which would be duly sent to the estate, and charged for at the highest rates, without reference to their quality. Thus, the manager might know excellent young cattle for sale, at 10*l.* sterling a head; which, being bred in the immediate neighbourhood, were precisely the description of animal required: yet he would not be allowed to purchase them, but be obliged to post off fifty or one hundred miles to choose from a "pen," cattle not in any way suited to the estate; having the additional mortification of knowing that they would be charged for at the rate of 12*l.* and 16*l.* a head, with the risk of one or more dying on the road home, and the positive certainty of one-half, or one-third dying before they had been on the estate three months! Did the manager venture to hint his disapprobation of this course, it would immediately obtain for him his discharge from the estate, and the lasting dislike of the agent or attorney,—and why? merely because the said breeding pens belonged to the attorney himself—to his relatives or constituents—and it was his interest so to manage!

I have known the same estate pay from 20*l.* to 25*l.* sterling for mules, for the same reason; when larger, stronger, and in every respect better mules could be obtained in the neighbourhood at 17*l.* and 18*l.* each! But was this estate an isolated case? Was it not a notorious, and almost universal, practice throughout Jamaica? Every planter must know that it was (and in all probability is still) carried even to much greater, and more fraudulent lengths; which were as universal as notorious! Surely this system throws considerable light on the mysterious non-progression of Jamaica estates; in so far as the obstinate perseverance in the use of cattle-mills; keeping up large herds of cattle on estates; the rejection of all improvement in manuring lands, and manufacturing produce; and the utter absence of all attention to the well-being and preservation of their horned cattle and mules are concerned!

We know that the average working period of a steer, or heifer, in Jamaica, under favourable circumstances, is ten years; but when a little extra care has been bestowed on them, we may safely reckon on fifteen years; whilst a mule, with common care, will work for twenty, thirty, and even forty years. I have had four mules, varying in age from forty-five to forty-eight years each, as proved by the most undoubted evidence; and all of them, at that age, taking their regular spells in turn. The attainment to these several ages may be very desirable for the proprietor and mortgagee; but it would be a very formidable affair to the agent who has "breeding pens" of his own,* and relatives or friends to patronize. How would he then manage to dispose of their cattle and mules? The more closely we examine this breeding-pen patronage, the more forcibly are we struck with its ruinous tendency. It has been the great obstacle to various improvements in sugar cultivation and manufacture; and must be put a stop to, ere the sugar estates can succeed. A steam-engine is incomparably cheaper and more efficient than cattle power. Long tops (the green leaves and upper portion of the cane, when cut), and the expressed cane stalks, green and moist, as they come from the mill (usually called green trash), furnish, in their decay, manure far superior to that of cattle; and coal offers a fuel, so abundant, cheap, and desirable, as to render it, in every respect, more suitable than dried cane-trash or magass.

What, then, keeps these from being brought into operation? Is it not, in nine cases out of ten, self-interest;

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* I have known attorneys send to the Spanish main and buy up a number of mules, which on arrival were sent to their breeding pens, *marked*, and afterwards apportioned off to the different estates of their constituents, and charged for as Creole mules.

which misrepresents facts, and conjures up difficulties that can have no real existence? Undoubtedly it is: and it serves to show the miserable condition to which the resident managing planter is reduced. In Jamaica he is termed "Overseer," whilst his assistants are named "Book-keepers."

But the overseer of the present time is very unlike the rude, untaught person of bygone days: he is now, generally speaking, of good family; well, and often even classically educated; and, consequently, possesses a superior and enlightened mind. Yet this class of men are treated with scarcely more consideration than the inferior class whom they have succeeded: they *must* do whatever the attorney may order, however arbitrary or prejudicial to the interests of the estate it may be; otherwise they lose their situations, and are thrown out of employment, perhaps for months! There is no communing with the overseer in regard to the welfare of the estate — no exchange of advice betwixt overseer and attorney: or at least, none which merits the title. In fact, the whole system is quite opposed to such confidence and consideration: the attorney employs an overseer who will manage the property he is placed on precisely as he directs, and who will bend to him in all things. The overseer, on the other hand, seeks to conciliate the good-will and secure the countenance of his employer, the attorney,—the only employer whom he knows—by doing all in his power to please him. He knows that at any moment, with or without a reason, the attorney may discharge him: is it to be wondered at, therefore, that he is cautious of saying or doing aught offensive, when it could only lead to his own loss of employment and attendant injury?

Of course it will be understood that there are many attorneys who are exceptions to the above rule: which I am sorry to say, however, is still but too general. Nor do I intend to assert that a very strict supervision is not necessary: on the contrary, I consider a proprietor or agent cannot exercise too much vigilance, or interfere too often, when he finds things going wrong on an estate. But I think that an overseer should be brought to identify himself with the property, of which he is in charge—that he should regard it as his comfortable and undoubted home; which he feels is secured to him by the good-feeling and interest of the proprietor or agent. Were such a feeling called into being, and carefully fostered, many very great benefits would result. For instance: take an intelligent and right-minded man, of education and experience, and place him in charge of an estate—giving him an honest account of its pecuniary position, a clear idea of what is expected from him, and a genuine assurance of confidence, security, and indulgent consideration—and I feel convinced, that he would study economy in the general management of the estate, and employ the energies of his mind in compassing its gradual improvement, instead of speculating on the advent of a *successor*.

At present, the great aim of an overseer is to keep his situation; which is generally of so insecure a tenure that he thinks it a folly to enter on calculations that require time to carry out. It is a most injurious system, and should, at all risks, be altered: for without feeling a heart-and-hand kind of interest in the estate that he manages, the overseer can never act the part he ought.

I have given an instance of a small estate, having cattle amounting in actual value to 2,800*l.* sterling, and making only 150 hogsheads of sugar per annum; besides incurring a yearly outlay for fresh cattle supplied in the place of those which have died! Is this not enough to make one stare? Can anything be conceived more ridiculous and extravagant? Let us contrast this with what an estate *really* requires, to furnish an out-turn of 250 tons of sugar. First, I hold it as indisputable, that 150 acres of land, cultivated in a rational manner, will, in seasons of ordinary character, produce that amount (250 tons) of sugar, and 100 puncheons of rum. Secondly, that the whole 150 acres are level, ploughable land. And lastly, that every simple and inexpensive improvement be availed of.

An estate, then, we will suppose, to consist of 500 acres of land, in cane pieces, grass pieces, common pasture, negro grounds, &c. &c.; one hundred and fifty acres constantly in cane, *id est*, 75 acres, plants, and 75 acres, first rattoons, every year, and the "works" in the centre of these fields; a good honest steam engine of ten horse power; improved evaporating pans and concentrator; with coals, as the whole and sole fuel;* and seventy-five good, strong young cattle, averaging 10*l.* sterling a head, divided as follows:—

Two ploughs of six cattle each, and three extra	15
For six light but strong carts, each six, and four extra . .	40
Breeding cows to keep up stock	20
Total	75

The fifteen plough cattle to be kept continually in stalls, and fed on dried grass and maize, or chopped tops; and the cart cattle in like manner, housed, and fed on dry food continually: except Sundays, when the whole, both plough and cart cattle, should be allowed a day's grazing.

In order to manage this, a certain number of acres of land must be kept planted out in guinea-grass for cutting—in which no cattle could at any time be allowed to feed—and the grass must be in regular lines, and at regular distances, so as to allow the plough and other implements being continually used through it. In this manner, guinea-grass pieces can be kept in excellent condition and constant fertility, at a mere nominal cost; whilst grass-cutters will cut, on contract, fifty bundles (each weighing over 30 lbs.) and lay them on the road, or interval, for the carts, for one dollar: which, under such circumstances, I consider a high rate; but I have often paid that sum in Jamaica. Now a horse will keep in excellent condition on three such bundles a day; but even allowing 200 bundles amongst fifty-five cattle, or an equivalent, dried, and I am certain that they would keep in the most admirable working condition.

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* The calculations which these involve are given further on.

These two hundred bundles would cost the estate four dollars, or seventeen shillings and fourpence, English money; and every planter must know that cattle so fed and tended will perform double the work they otherwise would, and that too, with perfect ease to themselves. But I propose giving the plough cattle, each, one quart of Indian or Guinea corn every day they work; not whole, but passed through a mill. This would be an extra charge of one shilling and eightpence a day, which would make the cost of supporting fifteen plough cattle, amount to about six shillings and threepence a day.

With such food and treatment, these cattle could work from six o'clock in the morning until ten; resting and feeding four hours, that is, until two o'clock; from which they would again work until six o'clock, altogether eight hours in the twenty-four; during which, each plough will turn up one acre of land thoroughly. It is quite useless for any planter to say, that cattle will not perform this work, for I know for a positive certainty that they can do so; having had six cattle ploughing, morning and evening, in all eight hours, for several weeks continuously, giving me one full acre a day, and rarely stopping work even for one day. More than this, my plough cattle, so treated and worked, grew fat on their work, and were never ill; but were in all respects the best conditioned cattle on the estate. The plough that I used was a small light wooden one, with an iron share, made by my own people; and cost about one pound sterling.

Nothing can be more simple than such an implement; and its efficiency is so great, that I would never desire any better ploughing than is performed with it. In Jamaica *four* steers could draw a similar plough with the very greatest ease and comfort; but I have made an allowance of six cattle to each, in consideration of stiff soils; and I am perfectly certain that, with such a number, each plough will most thoroughly turn up twenty-five acres a month (twenty-four working days). Including a ploughman at 4*s.*, and two boys at 1*s.* 3*d.* each day, this work would cost only 12*l.* 3*s.* 6*d.*; and if the same land had a further working up, as a harrowing, hainghering,* and trenching for cane-plants (each six feet apart), it would occupy one month longer, and cost an additional 12*l.* 3*s.* 6*d.*, making the perfect preparation of twenty-five acres of land amount to 24*l.* 7*s.*, or not quite 1*l.* per acre! After which, *one man* can easily drop the cane plants along the trenches (covering them *very* partially with his foot as he proceeds), at the rate of *one acre a day, for one dollar!* Thus two such ploughs would occupy only three months (or seventy-two working days), in ploughing, harrowing, hainghering, and trenching the whole seventy-five acres of land; at a cost to the estate, including planting (as before rated), of about 90*l.* sterling! whereas, according to the old system of digging cane-holes, the same quantity of land, dug and planted out, would cost 375*l.*! Now these two sums alone show the immense advantages derived from the use of the plough; but it is evident that we must look closely into several points which it affects, fully to understand the extent to which the planter's interest is influenced by it.

In the *first* place, we must consider the benefit which the soil derives from being so well ploughed up, harrowed, and pulverized, which may be said to consist in mixing up its various constituents; in moving and scattering about the excrementitious matter emanating from the roots of the cane; in loosening, pulverizing, and rendering porous, the soil, so that air and water can penetrate to perform their important functions (see page 46), and in eradicating all weeds and grasses.

Secondly, the certain, expeditious, efficient, and economical manner in which the work is performed. *Thirdly*, the great saving, both in "tops" and labour in supplying; as by this method, canes are planted in lines six feet apart, and full two feet distant from cane-top to cane-top, taking, in all, about 2,346 cane-tops to an acre; almost every one of which will grow, as the land is so well pulverized; consequently requiring little or no supplying. *Fourthly*, the facility with which the cultivator, hoe-plough, or plough itself, can be used between the cane-rows, for the purpose of eradicating weeds, and turning up the soil. And, *lastly*,—perhaps the most important of all,—the immense saving in human labour!

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* *Haingher* is an Indian implement used for breaking clods, pulverizing the soil, and smoothing over the land. It consists merely of a piece of rough timber usually eight feet long, eight inches broad, and three or four inches thick, and is drawn by four cattle; the two drivers standing on it whilst driving.

In a country where labourers are so scarce and high priced, how can any planter overlook so vital a consideration? Only reflect that fifteen cattle can be supported in good condition, and seventy-five acres of land can be admirably prepared and planted out in canes by the aid of *ten labourers only*, working seventy-two days! But, to carry it further, these same cattle have before them nine other months of the year, during which they are employed in the different fields, with cultivator, hoe-plough, and plough; cleaning, moulding, and banking the young canes; ploughing through guinea grass fields; carting manure from their own stalls; coals from the wharf; or other useful work. Whenever they are not at work, they are resting in their comfortable stalls, well fed and tended, and collecting a stock of strength and vigour, to be put forth advantageously whenever required. Cattle so treated, the planter may place every confidence in, when called on to perform hard work; and at the same time he may safely reckon their average period of service, from ten to fifteen years. Such animals would pay for themselves over and over again, and still, after their long and honest servitude, would sell to the butcher for almost as much as they originally cost.

With the forty cart cattle before allowed for, the same course of feeding and treatment would be followed, (with the exception of the corn)—which would result in the performance of double work, and a long career of vigorous health, and genuine usefulness to the estate. Carts can always be advantageously employed on work of one kind or another, whether in or out of crop time; but it is of considerable importance, that they be adapted to the description of work they may be required for:—a cane cart, a coal cart, a grass cart, and a sugar waggon or truck, each should be exactly fitted for its peculiar employment. Four or six cattle only should be used in each cart; if they are really good, strong animals, fed on dry food and carefully attended to, four of them are quite equal to the working of one large cart with its full load, wherever the roads are at all tolerable and level.

During crop time, bringing canes to mill, and returning with green trash to the field,* would constitute ample employment for all the cart cattle on the property; but out of crop, or when not so engaged, they should be kept constantly employed in bringing coals from the wharf,—manure from cattle pens,—sand from the sea-side (if the land requires it),—grass dried for stacking,—boards and other supplies from wharf,—in assisting in ploughing, cleaning, moulding, and banking young canes; or, indeed, in any or every kind of work, to which they can be applied. In this manner, forty cattle will perform an amount of work which would perfectly astonish a West India planter; whilst the actual number of labourers required to guide and direct their exertions and supply them with food, are only ten men and seven boys: in all seventeen persons!

Now the maintenance of forty cart cattle kept in stalls and fed on good wholesome dry grass, will amount during one whole year to	£203	0	0
And allowing that six carts and thirty-six cattle work five days in each week, or 260 days in the year, then the hire of thirteen persons is	325	0	0
Add to which, for the plough cattle maintained during nine months and working 180 days, including ploughmen, boys, &c., the sum of	202	0	0
And we find that for the very moderate total sum of	£730	0	0

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* Together with carting cane tops to different pieces requiring planting.

we can accomplish all the numerous and important objects above enumerated; to the great abridgment of human labour, and consequent saving to the estate itself: benefitting likewise the island at large, inasmuch as it serves to throw the amount of labour saved into the market.

I have made a calculation for twenty breeding cows also; which, of course, are under the care of a man or big boy, until they increase so much as to demand the assistance of a little boy likewise: altogether, during five years, their tending would cost about 175*l.*; whilst at the moderate calculation of fifteen calves a year, we might safely reckon, as follows, at the end of the five years:—

15	young cattle,	4	years old, value	£150
15	do.	3	,,	105
15	do.	2	,,	75
15	do.	1	,,	50
Total 60 young cattle.			Value	£380

Breeding cattle, properly cared for, will continue not only alive and well, but breeding, for fifteen or twenty years; as I have often seen, and had undoubted proofs of. I do not advocate, however, such aged cattle being kept for breeding; but would much rather fatten up the original stock for sale, and supply their places with their own young heifers.

It is possible that one or two of the working cattle may die during a period of five years; to replace which, it might be absolutely necessary to purchase others: but this could be only looked on as an advance made to the account of breeding stock, which they would quickly repay with compound interest.

The increase of these cows should, however, never be allowed to extend beyond a certain limit, but must be kept under, by selling off some of the old or young cattle from time to time: facilities for doing which to advantage, in Jamaica, are abundant. The positive gain to an estate by keeping such breeding cows, is of a threefold character, viz., the value of their increase over the sums expended for herdsman and boy,—the amount of manure which they would furnish,—and the perfect acclimation and adaptation of their progeny to the estate whereon they are bred, and would continue all their lives, over young cattle purchased in another part of the island: half of which would most probably die the first or second season, and occasion great loss and inconvenience to the estate.

These are very important considerations to a proprietor; and it will no doubt be argued, that cows are, even now, kept on Jamaica estates for these identical reasons: but I certainly do not reckon on the breeding cattle being kept in open, exposed, wet and filthy pens, promiscuously with the working steers, as they are in Jamaica. Were they to be so treated, I should not calculate on more than one cow in three bringing forth and rearing her calf: for, independent of the exposure to all weathers and wretched condition of the pens, the cows are always being gored and injured by the working cattle.

I think I have rendered it clear, that with fifty-five working steers, and twenty breeding cows (costing in all only 750*l.* sterling), — all the work that can possibly be performed by animal power on an estate can be most satisfactorily accomplished, and the supply of stock (more than) kept up continually. And when I say that the method laid down would effect a saving of full two-thirds the amount of human labour required by the old system, I am confident I assert nothing but what is borne out by everyday experience, and which every intelligent planter can readily convince himself of.

The only actual additional labour required in cane-fields, prepared, planted, cleaned, moulded, and banked by the plough and other agricultural implements, (as before described) is in thrashing lightly, once, twice, or thrice, as may be found necessary; and when ripe, cutting, tying, and carrying out canes, to the road or interval. If proper care has been taken, even carrying out canes might in part be avoided, as the carts could enter the fields, (having a wheel between each bank,) and half load: but in all such work I hold it to be far better to have light drays, made purposely, which could be drawn by two steers with every facility. They should be in size as follows—7 feet long, 4½ feet broad; with axles 7 feet wide, and wheels 5 feet high; felloes 4 inches broad, but very thin, and as light as they can possibly be made; and a pole or tongue in the centre as strong as is necessary, but on no account heavy. This pole should be made to turn over or slide under, so as to do away with the necessity of turning the cart round. A cart or dray of this kind, can be made so light, and yet so strong, that two cattle can work it with the greatest ease and success; so that two, three, or four, may be daily used in bringing out canes to the road and interval; and in carrying back green cane-trash (direct from the mill) to be thrown between the banks.

It is advisable to have one or more of these carts employed wholly in returning green trash (brought from mill-yard by the regular cane-carts) to the trenches, whilst the others are bringing out canes; but when employed in carrying trash, they must be provided with extra back, front and side pieces, to enable them to carry a large quantity of it at once: in the same manner as are English hay-carts, only substituting thin boards, or close bamboo work, for the open rail work common to the latter, so that none of the broken pieces of cane-trash may fall out.

It will here be noticed, that as all the upper leaves of the cane, (usually termed "long-tops") and the green trash (or expressed cane-stalks) are entirely reserved for the manuring of the fields from which they are cut, and are buried in the soil whilst they are yet perfectly green and moist, to serve as a "green-soiling;" so is it necessary to give the young canes whilst growing a good and high banking, in order, when the canes are cut, to cover over the accumulation of dry and green trash, by levelling the banks.

Labour being abundant and cheap in the East, I have always had this levelling performed by hand-hoeing; but

I have also fully satisfied myself, that it can be easily accomplished by an implement (hereinafter described) drawn by cattle, at a very cheap rate. The great difficulty, undoubtedly, is the cane-trash being in the way; but this obstacle is almost entirely overcome, simply by running the plough along the trenches, between the banks, and so opening a small furrow to receive the cane trash, before the labourers are sent to trash the canes; who then place the trash carefully therein, and trample it well down with their feet: this gives very little trouble, and allows of the plough again passing along, and returning the earth to its original place; thereby covering over the cane-trash, which soon rots. This is repeated each time the piece requires trashing: which may be twice or perhaps three times. But when the canes are going to be cut, there is no necessity for this: indeed it would be no easy task, as the canes very often are "laid," which would effectually impede the cattle. So instead, the plan is, to oblige the cane-cutters to lay the trash and green tops evenly and compactly along the trenches, clear of the banks; then over that, the green-trash must be carefully thrown; all which, if done properly, will allow of the banks being levelled, and the whole completely buried. All this extra trouble is, however, scarcely felt, as the heavy portion of the work falls on the cattle; which, as I before have shown, are perfectly capable of performing these tasks, without being overworked or distressed in the least. The only additional work properly belonging to the labourers, is the extra care they must take in laying the trash judiciously along the trenches; and the labour of about four boys in working the two green trash carts in the cane-fields, and returning it to be covered over. This is very slight indeed, but the benefit to the estate is immense; whilst the crops will continue for ages unimpaired: indeed I may say, improving. The system of burning off the cane-trash is most objectionable, and must never be had recourse to more frequently than once in five or six years; and not even then unless it is urgently demanded; for the ashes and feculencies from manufactories, manure from stables, cattle pens, and stalls, and other matters, will supply to the soil abundant assistance; which, together with the cane-trash and green-trash returned to it, and the frequent ploughings it receives, will render it sufficiently rich in every constituent.

In the common West Indian method of cultivating the cane, great difficulty arises in the disposal of the trash which obstructs the plough; the planter thereon makes short work of it by burning it off, and thereby depriving his fields of its valuable qualities as manure. But by pursuing the system of banking, the difficulty is removed; and, moreover, the whole of the necessary operations may be entirely performed by the plough and other implements worked by the cattle of the estate. It is very true that it entails some additional trouble, but so very trifling that it cannot be deemed worthy of mention, considering the numerous advantages attending.

To allow of the banks being levelled by machinery, as above mentioned, it is necessary that they should be made in straight parallel lines, otherwise the instrument could not work with certainty or success. This is very easily accomplished by a good ploughman, with anything like a steady spell of cattle. Indeed, it is astonishing to see the remarkable regularity of their work: I remember having had lands ploughed so exceedingly regular that any one would have supposed that I had had recourse to rule and line. But I have sometimes found it necessary to use a line or chain to guide the ploughman and boys; and whereever the levelling machine is to be used, I would strongly recommend it. My plan was to supply the ploughman with two long and strong cord lines, and three rods six feet long, with which they measured the distances and laid down the lines; the one at the extremity of the other, so as to attain a good length. The plough then travelled, on the right of, and close to, the line (throwing the earth to the right), the cattle walking one on each side of the line, so as to keep it between them. Arrived at the extremity of the line, the cattle halted a moment whilst the line was being advanced six feet; then proceeded down the same furrow (throwing the earth to the left), and up again along the line; and so on continuously, always returning down the same furrow, after the line had been advanced. In performing this kind of work, I always allowed one little boy extra, to lead the cattle; and by these means I have had fields trenched for canes in as straight and regular lines as it was possible. If it be desired to run a double banking plough along the furrows as a finishing off, it may be done with great ease, and at the expense of very little time; as four cattle and two boys will, with a light instrument, run through four or five acres a day, and give a very desirable finish to the furrows.

With such care, in the first instance, how easily are all the succeeding operations accomplished! with what certainty can we calculate on the efficiency of each implement employed! And yet this care entails little or no expense or trouble; it only requires the very slightest degree of attention, and will save a world of trouble, vexation, and expense in the long run. The planter must study these points closely, and apart from old prejudices; pursuing his experiments in good faith, and with a determined resolution of overcoming all seeming difficulties.

Before going further, let us take a brief review of the several successive operations required to be performed by animal power, as have been described:—

First. A very light iron or wooden plough, drawn by four or six cattle, gives the land a thorough turning up.

Second. A cultivator, or harrow, drawn by four cattle, succeeded by a "haingher," breaks up the clods, and pulverizes and smooths over the soil completely.

Third. Trenches are ploughed with a single plough (by rod and line) six feet apart exactly; finished off, if thought desirable, with a double-banking plough; and cane-tops planted, by hand, along them, full two feet apart.

Fourth. First and second mouldings are given with a moulding implement, which will be fully described hereafter.

Fifth. First, second, and third (if necessary) cleanings are performed with a cultivator, or other appropriate instrument.

Sixth. First and second banking are given with ploughs adapted to that kind of work.

Seventh. A furrow is made between the banks before each trashing of the cane (which may be twice, or perhaps thrice), to receive the leaves removed from the plants; after which, the earth is returned, covering over the trash, and filling up the furrow. A common plough performs this very well.

Nothing further is required until the canes are cut; when the first crop, as far as the cultivation is concerned, may be said to end, and the second crop commences at once, in manner following:—

First. The green trash, *direct* from the mill, is returned to the trenches of the field from whence the canes are just cut, by very light carts,* and thrown carefully over the dry leaves and long tops lying in the trenches between the banks.

Second. The levelling machine, drawn by six cattle, is introduced between the banks, which powerfully presses down the mass of trash, &c., and at the same time slices off from either bank, some four, six, or more inches of earth, and arranges it cleverly over the trash. This, repeated once or twice, as may be determined on, quite covers over the trash, and leaves the smallest possible amount of work for the labourers; which consists in their cutting, with very sharp hoes, the cane roots down to the bottom, and levelling the small portion of the bank remaining, so as to have the whole field, once again, quite level. In a few days after being so cut down, the stools begin to throw up numerous vigorous shoots or sprouts, which soon require a light moulding.

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* As described at p. 71.

Third. The moulding implement moulds the young sprouts, or rattoons, once, twice, or three times, as may be required, at intervals of time; it does not require to go so deep into the ground as to disturb the store of vegetable matter which lies buried in the trenches: so that by the time the second banking is required, the whole will have rotted away, provided the land be any way porous.

Fourth. The cultivator, or other instrument, will suffice to clean the young rattoons, should they require it, and keep them clean.

Fifth. The banking is performed as in the former year, with a plough, at intervals, as may be required; by which time, as I before remarked, all the cane trash of the preceding crop will have rotted, and become excellent manure.

Sixth. The furrows between the banks (for the reception of the leaves taken off in trashing) are again made and covered up as in the previous year; and the canes then remain until ripe for crop, when they are cut, and the second crop ends.

Being ended, it now becomes necessary to replant the land which has just produced its crop of "*first rattoon canes*," in order to follow up the system I am recommending; the same measures are, therefore, adopted as in the former case, as far as regards laying the dry leaves, long tops, and green trash, evenly in the trenches, and levelling the banks with the appropriate implement: but here the operation varies; for the common plough is set to work to level the small portion of the bank remaining, and to plough up all the old cane stools or roots, that the land may be entirely levelled, then harrowed over and hainghered, so as to be perfectly pulverized and smoothed. Whilst this work is in progress, a few active boys are employed in collecting and heaping up all the old roots in piles, for burning, when quite dry.

A line is then laid over the precise places where the trenches ran, and the plough at once opens a furrow along the line, returning down again, as before; and, if desired, is succeeded by the double-banking plough. The trenches are then complete, and ready for the reception of the cane-top plants; which of course, by this means, are made to grow exactly over the bed of rich, decaying, vegetable matter, accumulated in the trenches of the two preceding crops. Thus a manure most abundant, and of the most valuable description possible, is secured to the growing canes; and continues, year after year, to increase the richness and capability of the soil.

When ploughing over the old trenches, there exists no necessity for penetrating so deep as to come at the buried trash: on the contrary, care must be taken not to do so; and still a depth sufficient for all purposes may be attained.

The young canes then, as they grow, have between them and the mass of decaying vegetable matter beneath, a layer of soil, through which their roots penetrate with facility, and discover an abundant store of richest nutriment below.

But the planter will ask "What are we to do with our manure, resulting from cattle-pen and stalls, stables, and manufactory?" The answer is simple, but important: allow one-half to the rattoons, and the other portion to the Guinea-grass pastures. That for the rattoons must be applied to the young sprouts when about a month old, and may be carted along the rows, in the very light cane-carts mentioned at page 71; with which two men, with light shovels or dung forks, and one little boy to lead the cattle, will manure upwards of an acre a day. But immediately the manure is applied, the moulding must commence: no delay must occur; the two operations must be carried on together, otherwise the manure will lose a considerable portion of its virtue. That portion reserved for the Guinea-grass pastures should be deposited around the roots, and ploughed in during the rainy weather; by which necessary indulgence the grass will always be abundant and rich.

It may be a matter of consideration with the planter whether he will plant Guinea or Indian corn amongst his rattoons so manured, or not. From local circumstances, he himself can best calculate the expense attending the purchase of seed corn, planting it out (of course, by a simple drill), watching, and breaking it in; but he may most confidently rely, that if he breaks in his corn when the ears are just full and before the stalks and leaves become dry (that is to say, whilst both leaves and stalks are quite green and juicy), and will make the labourers lay them down, near the roots of the young canes, then put in his ploughs and mould over them, he does his canes an immense benefit: in point of fact, he gives them a "green soiling," which every planter ought to understand the value of. As to the ears of corn which he gathers from the field, it is a matter of no importance, as regards the actual fertility of the soil; for the leaves and stalks, being returned in a green and succulent state, more than abundantly compensate for their removal. But when farm-yard manure is applied, as above supposed, an additional reason in favour of planting corn exists; which is, the injurious effect on the juice of the cane, produced by an excess of nitrogen being supplied to the plant, in the ammonia contained in such description of manure; and which the growth and requirements of the corn, serve to relieve it from. It is eminently absurd, therefore, to say that it injures and impoverishes a cane juice: yet when I say this, I must be understood distinctly to allude to the corn plant being green and succulent, when ploughed into the soil.

I have now shown, I hope, that with fifty-five good working cattle, well fed and housed, and regularly worked, an estate of 150 acres in cane, can be worked, and made to produce, year after year, 250 tons of sugar; for no planter of experience can doubt that land so worked up and carefully cultivated, will yield two tons of sugar an acre, from plants, and one and a half ton an acre, from first rattoons,—even according to the old plan of manufacturing sugar. I have been careful to confine myself to the standard produce per acre, according to the old and very faulty methods of manufacture; but I shall have no difficulty, I apprehend, in convincing the reasoning part of the planting body that, by pursuing a more rational system of manufacture, nearly double the quantity of sugar can be obtained from any given quantity of cane, than hitherto.

It will be remarked, that I only calculate on "plants" and "first rattoons;" which arisesfrom a very strong belief, that it is in every possible way more truly advantageous to replant every second year, than to allow the rattoons to continue in the ground, yielding only one-half, or one-third what they ought to. It is only carrying out the Chinese principle of making land continue for a series of years to return the utmost amount of produce it is capable of: it is indeed the wisest, the truest, the best, and gradually the fact is forcing itself on the minds of our European agriculturists.

Every point that I have urged, every improvement that I have recommended, is within the immediate reach of every Jamaica planter who is connected with properties on which the plough can be used. I have not advised any plan that would carry expense with it, but really that alone which would save both labour and money: of money, which is scarce, very scarce; and labour, which is still scarcer, and more difficult to be obtained. With regard to this latter, I assert, that by the use of the plough and other proper agricultural implements, an estate can be carried on with *one-third* the number of labourers that are now required; and were it possible to use them on every estate, I am quite confident they would influence the price of labour as much as would the introduction of one hundred thousand labourers.

The labouring population of Jamaica, engaged in field labour, may, on a rough estimate, be set down at upwards of 150,000 persons; but we all know how very averse they are to anything like continuous labour. Hence it is that such an amount of labourers can scarcely be believed in, even by the planters themselves, although it is no less the fact.

Is it not wonderful that planters will not use the labour of cattle, which is abundant, to abridge human labour, which is so expensive and scarce? Is it not sad and melancholy to reflect on the fine level, workable estates which have been thrown out of cultivation, because men will not listen to the voice of reason, but rather, with a dire infatuation, cling with the utmost pertinacity and obstinacy to old and antiquated systems, which every succeeding day serves to prove mischievously wrong and ruinous? Nor is it from a want of advice, strongly and honestly urged, that they continue in error; for how numerous have been the exhortations to pursue a different course? how much has not been written on the subject? At this moment, I distinctly recollect how clearly and correctly the late Mr. W. F. Whitehouse, of St. Mary's, wrote about it, in his admirable "Essay on the Cultivation of the Sugar Cane," and his very excellent work entitled "Agricola's Tropical Agriculture;" yet it does not appear that much good has resulted. I cannot more distinctly express my opinion of Jamaica estates than by saying, that I think abandoned sugar estates may at this moment be purchased, and by common good management be brought again into cultivation, so as not only to pay their expenses, but to yield a handsome income.

I will take the case of a capitalist purchasing at auction, or private sale, an estate comprising good, level, workable lands, situate within a moderate distance of some good sea-port, who looks on the property as so much waste land, which it is his object to bring into cultivation and establish as a sugar estate, on rational principles, and by the aid of improved machinery. The actual expense which he would be saved (if any) would consist in buildings, roads, fences, negro houses, cattle pens, &c., &c.: but I hold even this saving to be very problematical indeed, inasmuch as in numerous cases the "works" are ill placed and exceedingly ill adapted to the purposes for which they are required: which may also be said of the roads; whilst the walls and quick fences may reasonably be supposed to be in the very worst state of dilapidation. Under these circumstances, the saving on these items may truly be considered as extremely equivocal; for we all know how much more expensive and vexatious it is to alter, repair, and patch up that which never was good, than to make an entirely new and useful article at once. However, knowing how very expensive building is, in Jamaica, I will suppose that the "works," dwelling-houses, negro-houses and cattle-pens, are allowed to occupy their original positions; and by slight repairs and alterations are rendered sufficiently serviceable. Next, that the outer fences, enclosing one hundred and fifty acres of cane and fifty acres of guinea grass land are repaired, and the roads and intervals cleaned and put in order, wherever they are found to answer; but ploughed up, and others opened out in their stead, when otherwise. That the enterprising capitalist erect a strong and serviceable high pressure engine of twelve or fourteen horse power, with suitable mill, evaporating pans, concentrating apparatus, and improved still.* That he purchase just as many cattle as will perform the work of his estate, and keep up the number; also, as many ploughs, harrows, cultivators, levelling machines, hoes, and other implements (of the exact description required), as are necessary, and no more. That his different carts, drays, and waggons, be light, and in every respect adapted to the work in which they are to be employed. In short, that everything on the estate be such as is demanded by reason and true economy; and that coals be brought from England direct to the nearest "port" to the estate, so that they be used as the only fuel, both for the engine boiler and evaporators, to allow of all the cane-trash being returned to the cane-fields. Lastly, that his canes be expressed thoroughly, and the juice be desiccated, evaporated, and brought to concentration, according to the most improved methods. Let any capitalist attempt this, and there cannot exist a single reasonable doubt as to its most perfect success. An estimate of such an estate, so established and so conducted, will be found in a succeeding chapter; and I shall solicit for it not only the attention of planters and capitalists, but also the most searching inquiry into every statement put forth in it.

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* Full particulars of all these will be found in the chapter on "The Works."

In the foregoing pages I have altogether based my calculations on the amount of labour now available in the West India Islands; but no one can in reason expect that things will be allowed to continue in their present ruinous course: the British nation cannot permit so dreadful a catastrophe as the utter ruin of our West India colonies to be consummated!

A people who have paid twenty millions of money to abolish slavery in our own colonies, and who still keep up a host of "cruisers," at an enormous annual expense, to obstruct the trade in slaves elsewhere, cannot—will not—surely debar our colonists from obtaining free labourers to work their estates, in order to compete with the slave colonies of other countries, now that slave-grown sugar has gained so much favour in this country! Justice, humanity, consistency, and the strictest national policy, demand the honourable support of our valuable colonies, and their preservation in all their importance and consideration. The dignity of the nation, its good faith and commercial policy, are alike deeply interested; whilst at the same time its wealth and resources place within its power the means of conferring on them the most substantial, as well as enduring, prosperity. Need I say, that the boon of all others which they crave, is a population—a well-ordered, industrious, and abundant labouring population; not the trash that are sent from India under the general name of "Coolies," costing from 15*l.* to 20*l.* each for passage alone: very far from such expensive and inefficient people; they want the intelligent, enterprising, and industrious Chinese; the best class of emigrants under heaven!

These are the people required in our fertile islands of the West: these are the men who will emigrate in thousands, and hundreds of thousands, to our sugar-growing colonies, if they can only get the chance of doing so;

these are the labourers who would, by their enterprise and untiring industry, support themselves in comfort, save the planters from total ruin, and raise our West India Islands to a higher pitch of prosperity than they have ever yet attained, even in their most palmy days.

A subject of such importance to every one in any way connected with the West Indies, and even to the whole British empire at large, must carry with it an intense interest; which will form a sufficient excuse for my introducing, in this place, the leading features connected with Chinese emigration to the West India Islands. I cannot find a more suitable opportunity of doing so, than the present part of my subject presents: for it will be seen, that I am now called on to notice the cultivation of the cane by means of the hoe alone; which appears to me to be entirely useless, unless we can convince ourselves that an abundant supply of labourers will, ere long, be bestowed on the West India colonies. My experience in Jamaica leads me to believe, that no estate throughout the island can at present be cultivated in cane by means of the hoe alone, without entailing a positive loss annually; and it therefore seems necessary to show how labour can be procured in sufficient abundance to bring estates (which are too rocky and steep for the action of the plough and other agricultural implements, save the hoe), within the limits of a remunerative cultivation.

Now, of all labourers who have come under my observation, I know of none who can in any way be compared to the Chinese, for enterprise, energy, sobriety, intelligence, application, physical power, determined perseverance, cheerfulness, and prudent economy combined.

I do not advance this on light grounds: on the contrary, I assert it as the result of the most mature consideration, of the most searching observation, during a period of sixteen years' actual practical experience, divided between the West Indies, Bengal, and the settlements in the Straits of Malacca; during which time I have had hundreds (I may say thousands) of

Negroes, Hindostanees, Bengallees, Chuliahs, Malays, and Chinese, working under my management and direction. It may then be conceded that I have had a fair opportunity of becoming thoroughly and practically acquainted with their respective merits, and relative value, as labourers. Under no other circumstances could I venture to speak so positively on so important a subject.

It is of no avail to question, at this distant period, the wisdom of the mode whereby emancipation was effected; but as an expression of opinion (which I feel satisfied will be acquiesced in by every thinking mind in the empire,) I cannot refrain from asserting, that, had Government, during the six years allotted as the period of "apprenticeship," introduced two millions of Chinese labourers into the West India Islands instead of the money-compensation of twenty millions sterling, emancipation might have taken place; to the glory of England, the benefit of the whole planting interest, and the lasting prosperity of those valuable and important colonies. We should then have seen no abandoned estates, no ruined planters, no general desolation, no universal despair: on the contrary, we should have had, at this moment, an extended cultivation, such as never has been; a thriving and happy body of planters; an enormous increase in all their staple products; a general activity and prosperity throughout these colonies; and last, though not least, two million customers for our British manufactures of all descriptions. I know that many will start at the idea of so vast an immigration as that of two millions of people; I know, too, that many mortgagees and other interested individuals would not have shown this plan much favour; but such selfish, short-sighted views are utterly insignificant, when put in competition with the general welfare and enduring prosperity of our colonies, and the mother country. But alas! an evil influence prevailed: the vast sum of twenty millions was distributed and squandered, without doing a real benefit to any; and now our fine colonies are hastening on, with railway speed, to a fearful and irretrievable ruin.

I have looked around in all directions, in order to discover some feasible means of arresting the impending final calamity; and although there are many improvements which can and must be made, still, the one great remedy undoubtedly is, the bestowal of an abundant labouring population! The money wherewith this object is to be accomplished must, in the first instance, be provided by the mother country, and a mode of repayment chalked out, which shall be at once just to the mother country, and sufficiently indulgent to the colonies. It must be with no niggard hand that funds are granted, but with the fostering liberality of a great and noble empire. No mean and paltry scheme should be for an instant entertained; for it would be unworthy of so opulent and mighty a kingdom, and, at the same time, would be perfectly certain to fail in its effects.

When we see our princes spending 80,000*l.* in the construction of a monkey-house, stable, or some such building! —when we see our noblemen spending 100,000*l.* in the erection of a single conservatory, or the completion of a yacht!—when we see our Government, with a noble humanity, granting a supply of 8,000,000*l.* to alleviate the distresses of Ireland!—when we see this, and a vast deal more of similar character, may we not be allowed the reasonable hope that the West Indies will be saved, ere yet too late, by a timely and adequate grant? Will a loan, based on just and reasonable principles, be refused them? I cannot think it will. Let us not doubt it, but proceed to investigate the measures proposed.

The nearest route from China to the West Indies is evidently that *viâ* the Sandwich Islands, the Isthmus of Panama, and from thence divergent to any desired point. Or by the Straits of Sunda, or Lombock: by taking either of which courses, the ship might take in a partial cargo of rice, either at Samarang, Sourabaya, or Lombock; thence proceeding *viâ* the Cape of Good Hope.

At present, about 25,000 Chinese labourers find their way from China to Singapore and Penang annually! Induced by absolute starvation, and a spirit of enterprise, to emigrate on speculation, they arrive in vessels of all descriptions and of all nations, crowding the vessel so much, that the owners generally make a handsome sum by their conveyance.

When the tide of emigration has once fully set in towards the West Indies, many no doubt would adventure to Panama, by every favourable opportunity; were they sure of meeting agents there, who would advance their passage-money for them, and forward them on to their destination.

I wish it to be distinctly remarked here, that I do not advocate this uncontrolled mode of transmission. Humanity is opposed to it. But I mention it as a peculiar feature in Chinese emigration, which demands a particular notice. For instance, they come to Penang on speculation, unprovided often with money or clothes, further than the ragged trousers they stand in; and enter into agreements with resident Chinese or European planters, to serve the first year for mere board and lodging, on the understanding that their passage-money be paid, and a coarse mosquito-net, mat, and two suits of cotton clothes, consisting of loose trousers and jacket shirt, be supplied them; the whole of which latter may cost about two dollars (8*s.* 8*d.*) for each man.

But this is a troublesome practice for any but Chinese to attempt; as many of the new-comers may not wish honestly to work out their time, and may therefore abscond, or may work so very lazily that the planter is wearied out: but with their own countrymen they cannot so easily play off their tricks. I, therefore, always thought it preferable for the European planter to send his head Chinamen (cultivating canes under contract) on board the vessel, and to let them choose as many men as were required, paying for their passage-money, providing them with necessaries as above, and giving them clearly to understand that they would at once be put on the same wages as all the other Chinese on the estate; from which a portion, month after month, would be deducted, to repay the advances made on their behalf. They were then distributed amongst the different contractors, who thus became their immediate masters; and were responsible for their advances, whilst they would take excellent care not to allow them to be idle or negligent on their work.

It will be seen that, either way, the expense of their passage and equipment on joining the estate falls on the emigrant himself; and he is only too happy at having by these means exchanged a life of comparative destitution and starvation for abundance and comfort. Now Chinese, for many years, have been accustomed to this kind of speculative emigration, both to British and other settlements; and this method of repaying, out of the proceeds of their labour, the amount advanced for their passage-money and necessaries, has become with them a settled custom: I hardly need say, that established customs have the strength, and almost the authority, of law with the Chinese. Hence I would wish to direct attention to these peculiar habits; and it will be found that they lead us to a not unsatisfactory solution of the great question of repayment of Government advances.

It may not be considered out of place to touch slightly on the subject of repayment here; nor will a few hints thereon be unwelcome to those concerned. First, then, we must consider on whom the repayment shall fall, and how long a period can be allowed for its being refunded.

Three modes of repayment present themselves to view as feasible. The first refers to the emigrant himself, who comes to the island to obtain a livelihood, such as he could not gain in his own country, and enrich himself; to assist the various members of his family, whom he leaves at home; and to accumulate a sufficient sum of money to enable him to return to China, and settle down comfortably.

A Chinaman always cherishes the idea of returning to his own country; but, after a lapse of many years, he is often compelled by circumstances to abandon it, and make up his mind to live and die in the country to which he emigrates. A family grown up around him; the death of all his relatives in China, save one or two, who remain to perform the usual annual rites at the graves of the departed; the accumulation of property, and the consequent fear of being plundered by the mandarins,—are amongst the chief inducements to remain; but there are numerous others also, which it would be tedious and useless to name. Every good Chinaman so emigrating, sends most punctually every year a sum of money, great or small according to his means, to his relatives in China, for their use, and to enable them to perform, in his name, the indispensable rites due to his departed ancestors; and, as I said before, often returns to his own country with the money he has accumulated. It is necessary to mention these circumstances, in order to show the benefits derived by the emigrant and his family from his industry; which, by Government having afforded him a passage to the West Indies, he has been enabled to bring to a good and sure market: as on this reasoning alone can we base our arguments in favour of throwing the whole or a part of the cost of passage on the emigrant himself.

We cannot fail to draw a distinction between an emigrant who settles permanently in a country, spending all his money in that country, and another who drains the country of its money, to send to his native home, during many years; and eventually returns from whence he came, with all his savings.

There is a very marked distinction between such emigrants; and it will be the more strikingly observed, if we only suppose an island—Jamaica, for instance—having a body of 100,000 Chinese, each, on an average, sending to China every year the small sum of five dollars = 500,000 dollars! Now, it is very evident that such an annual drain must be more or less felt by the colony from whence it is taken; and it forces on the mind the justice and necessity of looking to such emigrants for a refund of the whole, or at least one-half, of the sum expended by the colony in importing them.

Next, we must estimate the value of their labour and industry to the planter, on whose estates they work; and the general benefit to the island at large, resulting from their presence, their industry, their enterprise, and the local investment of a large portion of their accumulated capital. In the Straits Settlements, we have thousands of wealthy Chinese, who own ships, lands, houses, carriages, and horses, —men who are both liberal-minded and public-spirited;—men of influence, consideration, and authority;—men deservedly esteemed and highly respected.

Those who are acquainted with the Straits, know how true this is; but for the information of others it may be necessary to add, that several can boast of from 100,000 to 500,000 dollars; that one is a justice of the peace for Singapore and its dependencies; that the same man has built, and supports, a very handsome hospital and dispensary, for the benefit of sick Chinese; that others contribute to the support of European charities, and once even went so far as to join in a subscription for the alteration or repair of the European church, to which they did not belong; and lastly, I may mention, that on the death of a poor, ruined man, but a most honourable, worthy, and excellent person, named Tan King (familiarly called Tom King), every one hastened to testify his grief and respect—merchants, planters, the officers of her Majesty's ships of war, the military, merchant-captains, and others—all attended his funeral procession; which was preceded by the band of Admiral Sir Thomas Cochrane, sent for the especial purpose of doing honour to his memory! If I need say more to show how much the Chinese benefit every country they go to, I would ask the simple question:—Singapore, with its astonishing commerce; Penang, with its also very respectable trade; Province Wellesley, with its numerous fine sugar estates, spice, and other properties; and Malacca, with its quiet and substantial respectability;—what would they all have been at this moment, had it not been for the Chinese emigrants? And ringing echoes answer—What?

We find, then, that if Chinese emigrants (and their families in China) derive benefits from the countries to which they emigrate, they also confer benefits on those countries; benefits, too, of the most substantial character. Under these circumstances, we must recognise a mutual obligation —a reciprocal benefit; and we must therefore in justice, I think, debit the country with a share of the cost of bringing about this desirable junction. But the question next arises, how we are to raise the half share of cost: is it to resolve itself into a simple claim on every planter who employs these emigrants; or is it to assume the shape of a general "emigration-tax," falling on all throughout the island, in manner to be elaborately calculated and decided on by those in authority?

If it be an equal division of cost betwixt the emigrant and his employer, then the most simple arrangement serves to bring the whole matter into easy working order; and it strikes me that this is not so objectionable a method as it at first sight appears to be; for it is clear, that as no portion of the amount would in this case fall on the merchants, shopkeepers, and other inhabitants, they could more cheaply supply to the labouring population the necessaries, comforts, and luxuries of life, and thus enable the emigrants and other labourers to accept a lower rate of wages than they otherwise could: so that, on the whole, it appears to me that things would settle down very satisfactorily, and quickly find their proper balance. But if a general "emigration-tax" were resolved on (as the whole country would benefit alike), it must then be decided how such a tax should be levied. I am apprehensive that an immigration tax would raise up numerous sectarian opponents, on the score of its bearing on the present labouring population; its object being to introduce rival labourers. I cannot say that I am prepared at present to offer any suggestion on this point, but will venture a few remarks on the equal division of cost betwixt employer and emigrant, and forms of agreement.

Form of Contract between the Planter and the Chinese Emigrants.

Government Emigrant Office, Kingston, Jamaica.

I, the undersigned James Smith, proprietor (or agent) of the "Hope Estate," in the parish of St. Andrews, do hereby agree and contract, as follows, viz.:—

First. "To employ on my said estate for the space of twelve months from this date;—Lim Atchong, Lim Attyee, Lim Allowee, Lim Affook, Lim Sam, Lim Amafoon, Lim Atchee, Lim Sing, Lim Apwhee, Lim Attong, Chinese labourers, all of the tribe "Lim," paying them each at the rate of five Spanish dollars a month (of thirty days), allowing them Sundays.

Secondly. "To advance and pay on their account to John Brown, Esq., one of her Majesty's emigrant agents, the sum of four pounds (£4) for each labourer aforesaid; being one-half the amount expended by Government, in importing them; which sum to be refunded to me by a monthly deduction, from the wages of each, of two dollars and a half ($\$2\frac{1}{2}$).

Thirdly. "To provide, for the residence and accommodation of the said labourers, a comfortable house or portion of a house, with medical attendance and medicines, if they desire them.

Fourthly. "To allot to each, one-quarter of an acre of land for provision and garden ground.

Lastly. "In consideration of the services of the said labourers being secured to my aforesaid estate, by the annexed contract made and concluded in the presence, and with the sanction, of her Majesty's said agent, John Brown, Esq., whereby they bind themselves well and truly to serve me during the space of one year, I further promise and agree, and hereby bind myself, and my aforesaid estate, to pay into the hands of the said John Brown, Esq., or his successor or successors, for her Majesty's Government, the sum of forty pounds (£40), (being the second half of the amount expended by Government in importing the said ten Chinese labourers), in four quarterly instalments of ten pounds (£10) each.

"In witness whereof, I hereunto attach my name and seal, in the presence of John Brown, Esq., one of her Majesty's emigrant agents, this —— day of January, A.D., 184—.

"Witness to the above,
(Signed) JOHN BROWN, Emigrant Agent, and others, as may be.
(Signed)
JAMES SMITH."

FORM OF CONTRACT BETWEEN THE CHINESE EMIGRANTS AND THE PLANTER.

Government Emigrant Office, Kingston, Jamaica.

We, the undersigned Chinese emigrant labourers,—Lim Atchong, Lim Attyee, Lim Allowee, Lim Affook, Lim Sam, Lim Amafoon, Lim Atchee, Lim Sing, Lim Apwhee, and Lim Attong, do, with and by the sanction of John Brown, Esq., one of her Majesty's emigrant agents, hereby jointly and severally agree and contract to serve as labourers on the "Hope Estate," the property of James Smith, Esq., during the space of twelve months from this date; that is to say:—

"That we will labour from six, until eleven o'clock, A.M., and from one, until six o'clock, P.M., during six days of each week; in any work connected with the said estate, that we may be ordered to perform:

"That we will well and truly obey all the just and lawful commands of the said James Smith, Esq., and of those whom he may appoint to superintend and direct our work, and perform all our tasks and duties on the estate, in a cheerful and faithful manner, during the aforesaid period of twelve calendar months:

"For and on account of the following advances, payments, and other considerations:—

Firstly. "That the said James Smith, Esq., do at once advance and pay on our several accounts to John Brown, Esq., her Majesty's emigrant agent, the sum of four pounds (£4) for each of us, being half the amount expended by Government, in bringing each of us from China, to this island, the which sum we hereby jointly and severally bind ourselves to repay him (the said James Smith, Esq.) out of our wages; and accordingly authorize him to deduct from our wages, the sum of two dollars and a half a month from each, until the said advance be fully paid.

Secondly. "That the said James Smith, Esq., do pay us each five dollars ($5) a month as wages (subject to the deduction aforesaid), during the term of the contract; always understanding that we work twenty-six days in each month, and have Sunday as a day of rest. But in case of either or any of us absenting ourselves from work, without permission, it is distinctly understood, that payment for time so lost shall be stopped; and if of frequent occurrence, we submit ourselves to such other punishment, in addition, as the law may direct.

Thirdly. "That a dry and comfortable house or portion of a house be provided for us; that a quarter of an acre of land be allotted to each of us for garden and provision ground; and medical attendance and medicine, if we require them.

Fourthly. "That James Smith, Esq., do (also) pay at his own proper cost to John Brown, Esq., her Majesty's said emigration agent, the sum of forty pounds (£40), being the second half of the amount expended by Government in bringing us (ten) from China to this island.

Lastly. "That an 'interpreter' of some description be kept on the Hope Estate, who can communicate between our employers and ourselves, that we may understand all orders correctly.

"In witness whereof, we hereunto attach our names (or marks), in the presence of John Brown, Esq., one of her Majesty's emigrant agents, this ——— day of January, A.D., 184—.

"Witness to the above, (Signed) JOHN BROWN, Emigrant Agent, and others, as may be."	Chinese signatures follow here.

These forms appear to me to embrace all that is necessary: but to be quite understood, a few remarks in elucidation are required.

First. I make the period of engagement one year, as I am quite sure that term will be found of most advantage to all parties; for the residence of one year in the island will have made the emigrant acquainted with the country; his ability to support himself, partially, from the produce of his provision ground or garden, his poultry-yard, his piggery, and other *ad interim* occupations; and opened to his view his position and prospects; all which will enable him to judge how he may best pursue his favourite mode of working, viz., by contract,—to which happy course I look for the most beneficial results to the planter and the country generally. Besides, during the continuance of the twelve months' contract, the Chinaman would look on himself as working out his passage-money, and fitting himself for a position in which he could make the most of his labour. He is a truly speculative and enterprising character, and would, during the whole twelve months, be longing for its termination, that he might join some of his friends in taking a quantity of land on the estate, to cultivate by "contract," receiving payment according to the quantity of produce yielded by it. For my own part, were I the manager or proprietor of a West India estate, and obtained, for instance, one hundred Chinese emigrants on the terms above supposed, I would pick out a few of the most intelligent and influential amongst them, and take pains to point out everything connected with the country, the markets, and the capabilities of the estate; laying before them the advantages of at once resolving themselves into "congsees" or companies, and taking land on contract.

These would, I think, under the circumstances, succeed best when consisting of twenty-five men to each; two of the number being the heads of the congsee. They would joyfully enter into such arrangements, and the planter would find himself at once relieved of full half his trouble and anxiety, in the management of the estate.

However, to proceed. Next I have written their names in full, attaching to each its prefix, which in this case I have supposed to be " Lim," denoting that the man is of that tribe; and I think it a good plan to place those of the same tribe in the same " form," if there be a sufficient number. Now, I have supposed only ten persons to be included in one form; but it is quite unimportant how many are included: indeed I see no reason why twenty, fifty, or one hundred even, should not be all together in one form; although, if the stamped forms are cheap (as they ought to be), there is no object in so crowding them together. One form would be kept by the emigrants, another by the employer, and a duplicate of both by the emigrant agent in his register.

Sunday not being a holy day with the Chinese, is not kept by them as such; therefore they would rest themselves, work in their gardens, visit their friends, and amuse themselves on that day: perhaps attend the morning market, if one were allowed. But, quite independent of this, they would be sure to depute certain of their number to market, at least once a week, to sell their vegetables, and purchase for themselves little supplies of salt provisions, tobacco, spirits, rice, flour, ground-provisions, and other necessaries: but of course the persons so absenting themselves would require permission; otherwise the payment for the time lost, would be stopped, which would be absolutely necessary to hold them in check. I have also taken £8 as the sum which each would cost in all probability, in their passage from China to Jamaica: the which I am quite prepared to show is ample; and I have premised that the planter pays the half of that sum (for each man he employs) at the time of signing the engagements.

It might be made payable one month after; but I am more in favour of its being paid down at once.

In regard to this advance being repaid by a monthly deduction from the wages stipulated for, it does not necessarily occur that the planter would, or should, demand it the first or even second month: not at all events, to the extent of two and a half dollars; because, on arriving in so abject a condition as they would be, they may reasonably be supposed to require many little things—as clothes, cooking utensils, mosquito curtains, mats to sleep on, and coarse blankets—which they would be able to provide more cheaply, if allowed to purchase for themselves.

The sum of two and a half dollars, which remains to each man for his monthly support until his advance is refunded, may also be considered too small to be adequate to his support; but I am convinced that it is quite sufficient; for, in the first place, Chinese always mess together in companies of sometimes twenty, thirty, forty, or fifty, so that their cookery is all on a large scale, and according to the truest principles of domestic economy; they are also singularly cunning in the art of cookery, and will get up a savoury dish out of such poor materials, as would fill a French artiste with despair. Besides, with garden and provision grounds, they would speedily have, not only abundance of vegetables and provisions for their own consumption, but they would perfectly inundate the neighbouring markets with them; thus obtaining the means of procuring all manner of supplies. The only period during which they would labour under some difficulty, would be during the first three months, whilst their vegetables were growing: which, amongst other reasons, made me remark, that they would require some indulgence in regard to their deductions at first.

The residences or houses provided for the Chinese, should be large enough to lodge some twenty-five or thirty of them; as they like to live together, and have things in common.

The next item we come to, is the half amount of passage-money; which has already been partially discussed. I do not think it necessary to add more here than to direct the attention of all concerned, but the planter especially, to the point whereon the whole, after all, hinges; viz. the actual sum his labourers have cost him, on an average, each month, during the year for which he engages them: it will be found that it amounts to about 1*l.* 6*s.* 8*d.* sterling each man, not including medical attendance, or medicines: which I fancy will be very little, as the Chinese do not like European medical treatment. Nor have I included house-rent or land-rent, both of which must enter into the estate's "general account."

One pound eight shillings and four pence a month, of twenty-six working days, gives a fraction more than a shilling and a penny a day; which is as cheap as, I think, under the circumstances, the planter can reasonably expect at first: although, after these emigrants have properly settled down in the country, the price of wages will certainly have a downward tendency; as they will undoubtedly raise a large amount of provisions and other necessaries of life, which, thrown into the market, will cheapen those commodities throughout the country, and consequently lessen the price of wages. I should like to know what planter (in Jamaica, for instance), would not rejoice to have such excellent labourers as the Chinese, at thirteen pence a day; and as I do not believe there can be one who would not gladly employ them at that rate, so am I convinced that none can consequently object to the equal division of the emigrant's passage expenses, between employer and emigrant, as I have suggested.

With this hurried statement of the means to be adopted in order to repay the sums to be advanced, in the first instance, by Government; let us now proceed to discuss the extent to which it is necessary to carry this scheme of immigration, and the methods whereby I propose accomplishing it.

As was before remarked, the scale must be large, to be of any utility; and yet I have not calculated for so many as the islands could give food and employment to;—no, not even a tenth part of the number. I will merely provide for a present and immediate supply, leaving it to after arrangements, and progressive increase, to swell the number to its full requirement.

The number, then, for which I reckon, is two hundred and fifty thousand men and women for the whole of the West Indies: *id est*, for Jamaica, 100,000; Demerara, 50,000; Trinidad, 50,000; and the remaining 50,000 apportioned out amongst the smaller islands, as may be deemed expedient. It would be difficult, at present, to estimate the number of women who could be induced to emigrate with the men; but I have not the smallest doubt that any number required could be found heartily willing to try their fortunes abroad, in company with their countrymen. It is beyond all question that they *do* emigrate, and in great numbers too; for I myself have seen many hundreds who have done so. I have been informed by the most intelligent Chinese, that no difficulty exists at the northern ports; and that, as to the prejudice which is so much dwelt on, in reality, no greater prejudice exists among the women than amongst the men: in short, that both are only too happy in having an opportunity afforded them of exchanging squalid misery and positive starvation for comfort and abundance.* Whatever number of women actually do adventure, may be considered as permanent settlers in the country to which they go; and these will become the foundation of a race of pure Creole Chinese, with whom those colonies will, in time, be peopled; and by whose industry and energy they will continue to flourish for generations to come. It will be advantageous, therefore, for a large proportion of women to be brought; as they will also be the means of fixing in the country those of their countrymen who marry them: besides this, the planter will find them exceedingly useful in light work, on properties (especially in picking coffee and pimento, &c. &c.), as they are very industrious; and they will also prepare at home the meals of their husbands and friends, attend to the garden, poultry, pigs, children, &c. &c. or go to the market and buy and sell, whilst the men are working in the fields.

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* The circumstance of no women arriving with the male emigrants, on board the many European vessels coming to the Straits, induces many to think that women *won't* emigrate; whereas, on the contrary, it arises from the very speculative nature of such emigration, and their being entirely dependent on an immediate engagement, to enable them to pay their passage-money. In the Chinese junks, however, this obstacle does not exist; hence, we find that women *do* emigrate by these vessels.

One very serious error must be carefully guarded against, which is the sanctioning, on the part of any Government emigrant agent, contracts between female emigrants and householders in towns. No doubt, many townsfolk, of all conditions and of both sexes, will wish to obtain them as house-servants, ladies' maids, &c. &c.; but it should, on no consideration, be allowed. They come to the country for the purpose of becoming wives to their countrymen, and rendering them contented and happy in the country they have settled in: would it then be wise, just, or humane, to allow this important object to be defeated?—to have them engaged as house-servants in town, where they certainly would, most of them, become common prostitutes? Such a thing must not be even contemplated: they come for a specific and highly important purpose, and if that purpose is to be frustrated, then they had much better remain where they now are.

In mentioning the importation of women as well as men, I should have touched on the method of repayment to be adopted by the planting community, wherever they are concerned. However, a few sentences will suffice to express my views on that subject.

I do not suppose that a greater proportion than ten per cent.* would be calculated on, at the commencement: I therefore reckon ten women to every ninety men; and it must be incumbent on every planter taking emigrants, that he take them in that proportion. For instance, a planter requiring one hundred emigrants, takes ninety men and ten women; each of the latter pairing off with the man of her choice, so that the ten pair can come under contract together, in one separate form; the husband and wife becoming jointly responsible to the planter for half her passage-money; and the other half the planter himself must pay, as in the case of the men. Of course the husband's contract is similar to that of the other male emigrants.

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* I believe it quite possible to obtain fifteen, twenty, or twenty-five per cent., if considered desirable.

It would not be wise to press them (the women) into work for the estate, for wages; as they would be much more legitimately employed in attending to the cooking and other domestic matters, contributing to the comfort of their husbands and countrymen. I cannot think the planter would be so blind to his own best interests, as to demur to the payment of half, and the advance of the other portion, of these women's passage-money; for he may rest assured that the money so advanced would be punctually repaid; and the other half would be, indeed, nothing to him, in comparison with the stability it would give to his estate, by fixing families on it.

But I am sure that I need not dwell on this point, as I feel convinced that every planter will be exceedingly anxious to obtain such advantages as must result from women settling down, as these would, on their estates. As to their being kept amongst the men as mere prostitutes, such a case need never occur; and, I am perfectly certain, it would be of very rare occurrence indeed, were proper measures adopted to get them married off according to their own customs; which both men and women would be very happy to do: once married, there would be no fear of their prostituting themselves, any more than there would be amongst our own people; indeed, I am inclined to think, not so much.

At the time of the emancipation, Jamaica had a labouring population of upwards of 300,000 persons, men, women, and children, both old and young; but I do not suppose that more than 150,000 at present engage in field-labour: and even these, we all know, only work by fits and starts.

No one, then, will attempt to say that 100,000 Chinese could not find employment, at the rate of wages I have premised. Were we to say double, or treble, the number, it would be nearer the mark. I feel confident that, were Government to proclaim its intention of commencing at once the undertaking, every planter throughout the country would come forward, money in hand, to secure labourers, on the terms I have set forth; so that we may safely calculate, I think, on one-half of Government advances being paid down, within three days of the arrival of every ship-load of emigrants, and securities given for the payment of the other half also.

In Demerara, Trinidad, and the other islands, the same anxiety would be exhibited, and the same alacrity in bringing forward the money to repay the advances made by Government.

It is now necessary to advert to the management of the engagement, shipment, provisioning, and passage of the emigrants; and the actual sum it will, in all probability, cost to land them in Jamaica.

It would, of course, be necessary to appoint respectable agents in China, at the different ports,—Amoy, Shanghae, and Hong Kong—to procure, and ship the emigrants; and the full success of the project very much depends on the proper selection of these officers. Their duty would consist in choosing good strong young men and women; providing them with the very few necessaries required for the voyage; procuring good sound wholesome ships to convey them to their destination; to see that these ships are well found in necessary articles to support the emigrants; and, in short, to attend to all the many matters of detail, incident to such an office. The point being to land the emigrants in the West Indies, in the safest, cheapest, and most expeditious manner, the question presents itself, whether the route *viâ* the Sandwich Islands and Isthmus of Panama, cannot be availed of, as well as that *viâ* the Straits of Sunda, and the Cape of Good Hope. The distance, as I have before remarked, is very considerably less; and a great recommendation consists in the mildness of the temperature, as well as weather, to be expected betwixt China and Panama, in comparison with that *viâ* the Cape of Good Hope.

The one is a summer trip, whilst the other has the storms and cold of "the Cape" to contend against. But if the Panama route has its recommendations, it also has undoubted difficulties: these consist in the want of return cargoes from Panama for the shipping, which might take emigrants to that point, and the providing of vessels from Chagres to the West Indies.

The former difficulty, however, is that which is seriously important; because, unless a vessel can obtain a return cargo, the rate of passage must be high to enable her to pay her expenses and secure a reasonable profit. It would only be under two circumstances, therefore, that we could calculate on vessels taking emigrants to the Isthmus of Panama from China. The first would be in case of English, American, or other ships proceeding from the East to the South American coast (from Guayaquil to Valparaiso) for a cargo; or to the North American coast, California, Oregon, &c. The second would be, provided the rate of passage money were sufficiently high to keep the ship running between the ports independent of freight; which she would, therefore, only take in, if any offered, as a chance profit.

In the first instance, we will suppose the ship leaving the East for the South American coast; loading with rice at Penang or Singapore, for China; taking in emigrants at Amoy, together with a few boxes of tea and other articles; then running to Honolulu in the Sandwich Islands; there discharging and disposing of as much of her cargo as she could, and taking in whatever cargo would best suit her interests; then proceeding to the Isthmus, landing her passenger emigrants; and from thence to whatever part of the American coast she might have fixed on: which would doubtless be the different ports in succession lying in her course southward, so rounding Cape Horn homeward. This is decidedly not an unprofitable route for a good roomy ship to take; and, amongst the American shipping, would be far from an uncommon one.

Next, we will suppose a ship in the same manner bound for California and Oregon, taking in emigrants in China, together with tea, sugar, spirits, &c., &c., as part cargo; calling at the Sandwich Islands, as in the last-mentioned case, and so on to the Isthmus; then, having landed her emigrants, bearing up for California and Oregon, and there disposing of her partial cargo. Being now in this part of the world, it next becomes a question, where to proceed to, and the course appears clearly to be to load at once with wheat, flour, salt fish, and other products of Oregon and California, which meet a ready market in the Sandwich and adjacent islands; or to load for home direct, should inducement offer.

Lastly, we will suppose vessels kept constantly running from China to the Isthmus, and back again, altogether dependent on the passage-money of the emigrants to pay their expenses and return a profit. Under these circumstances, the features of the case alter very materially, and we have first to inquire for what sum well-appointed ships can keep the sea per annum.

This question must be again divided under two heads, viz., British and foreign ships; as foreign nations sail their vessels so much cheaper than we do. To begin with the British: we find that a 500 ton ship can be sailed cheaper in comparison, than one of 300 tons, and is besides, of a more eligible size for the purposes under consideration. She could carry fully 350 emigrants, and still have room to stow all her stores and provisions, together with 300 or 400 tons of cargo, should any occur. Calculating then the voyage at an average of six months, she would perform two such voyages in the year; landing 700 emigrants: for which, if paid at the rate of 8*l.* each, she would receive 5,600*l.*; deducting from that 700*l.* for provisions, the sum of 4,900*l.* only, would be left to account of the ship, or about 408*l.* 6*s.* 8*d.* a month.

Now the question is, whether British ships can be sailed at that rate to a profit; and if not, whether any cargo is likely to offer from China to the Sandwich Islands and Panama—or from Panama and the Sandwich Islands to China—which being added to the above-named sum, would bring it to a remunerative standard. Some ship-owners estimate the expenses of sailing their vessels as high as 20*s.* per ton a month; which makes a 500 ton ship amount to the enormous sum of 6,000*l.* per annum: but this seems a very excessive rate; which by our ordinary calculation, it would be difficult for other than a ship-owner to arrive at. Others calculate at 17*s.* 6*d.*; whilst others again reckon it at a still lower rate per ton. This is a question, however, for the shipping body to decide; and it is simply whether ships can afford to land Chinese emigrants at Panama for 8*l.* sterling each, or not. At this rate, even, it would still cost other 30*s.* or 2*l.* each, to land them in the West Indies: making 9*l.* 10*s.* (or 10*l.*) each labourer. It therefore would seem that by this course (*viâ* Panama) emigrants would cost from 30*s.* to 40*s.* each, more than if they went *viâ* the Cape of Good Hope. This is altogether caused by there being no trade on the line betwixt China and Panama, which would afford cargoes and return cargoes to the vessels engaged in this transport of emigrants. Betwixt the East and West Indies, however, this objection does not exist, as I will proceed immediately to show. But previous to doing so, a few further remarks on the Panama route may not be inapplicable.

In regard to the long-talked of canal or railroad, which is to connect the Atlantic and Pacific Oceans at Panama: the perfect feasibility of constructing a canal for ships across the Isthmus, has, I believe, been long completely established; and the causes that have hitherto operated against its being accomplished, have been chiefly of a political character, rather than the difficult nature of the country and undertaking generally. In the estimates which have been before the world, the cost of labour has been rated very high, and even the necessary supply of labour has been by some regarded as a serious obstacle; inasmuch as an adequate number of people were deemed unattainable.

But China affords labourers of the very best class, who are to be had in any numbers, not only for our colonies, but also for the formation of the much desired canal across the Isthmus; and the numbers who would be employed thereon could draw a large portion of their supplies of food from the East, by the vessels constantly arriving with emigrants from China: thus, together, each project might be pursued with benefit to the other. There certainly is no present trade to induce ships to sail between the East and Panama; but were attention once directed to the latter point, no doubt a traffic would speedily arise. The conveyance of emigrants across the Isthmus, and the construction of the canal, would soon induce the establishment of numerous branches of commerce.

Thus far have we discussed the question in regard to the conveyance of emigrants in English ships alone: we come now to consider the reduced cost at which foreign ships would engage in their transport; and a few words will suffice to explain what is necessary. Generally speaking, I believe that foreigners sail their ships at little more than half the expense that we do. And whilst we keep this in mind, we are by no means to run away with the idea that no other than English vessels are good. Far from it. Let us look at the American, French, Dutch, Spanish, Austrian, Portuguese, and other vessels, and we find many noble and excellent craft amongst them; especially the American: they are not only efficiently manned, but are clean, well-rigged, and well-provisioned craft; which certainly, on an average, make passages much quicker than ours.

The conveyance of emigrants from China being open to foreign, as well as British vessels, the agent or agents in China would only have to choose those which are staunch, roomy, well-found, and otherwise eligible in all points; and to see that they strictly comply with the various terms and conditions necessary to be imposed on them. Ships, of whatever nation they may be, should be availed of: provided, of course, they are in all respects suitable; and every restriction which is vexatious and unnecessary should be removed. Under even existing circumstances, no objections can be made to the employment of foreign vessels, in conveying Chinese emigrants from China to Panama: as these are both foreign countries; and certainly none should be tolerated were it even otherwise.

Were foreign vessels allowed for this especial purpose, there can exist no doubt that emigrants could be landed at Panama for less than 6*l.* each; which would admit of their ultimately reaching their destination in the West Indies, at a cost of 8*l.* each emigrant.

Once landed at Panama, the emigrants start on foot, accompanied by guides, across the Isthmus; each person carrying a provision-bag, weighing, say 20 lbs. containing rice, salt fish, and spices, to support him on the way, and last him during his passage to Jamaica (for instance). Crossing the Isthmus on foot, unencumbered (except by the trifling weight of the provision-bag) would occupy, at the very outside, five days; and allowing other ten days to reach Jamaica, we have a total of fifteen days: for which time the above weight of provision would be ample. Vessels generally make the run from Chagres to Jamaica in from five to ten days; and were this route adopted, many vessels from Santa Martha, Carthagena, and other places, would touch at Chagres on their way to Jamaica, on purpose to take up emigrants. Besides these, many others would offer, induced by the rate of passage-money, and the very few days occupied in the run. The arrangements necessary for emigrants crossing the Isthmus are very simple indeed, and the road quite practicable.

The route, *viâ* the Cape of Good Hope, is that which hitherto has been deemed the most eligible, and may probably be that finally determined on. I will therefore briefly allude to a few circumstances bearing on that particular course.

We may calculate the passage from Amoy, *viâ* the Straits of Sunda and the Cape, at an average of 120 days; or, if unusually long, 135 days. But ships pursuing this course would be able to avail themselves of advantages which that by Panama does not at present afford. These consist in the cargoes which they could obtain for the West Indies, in addition to the emigrants they may be allowed to carry.

There are, no doubt, a great number of articles produced in China, which would form very desirable and lucrative shipments to the West Indies, were the direct communication once fairly opened; but altogether apart from these, we know that rice in very great abundance can be obtained at Lombock, Sourabaya, Samarang, &c. &c., of excellent quality, at about 3*l.* 10*s.* to 4*l.* per ton, which shipped to the West Indies, would pay a fair freight, and leave a handsome profit besides, when sold. Thus, a ship of 500 tons could take in 300 emigrants at Amoy, run down to Lombock, fill up with 400 tons of rice, and then bear away for the Cape; and this she could do without going out of her course (materially), or losing, perhaps, more than two or three days thereby. American ships would very probably also, in many cases, be glad to take in one or two hundred such emigrants, in addition to their cargo, and land them in the West Indies, on their passage to America. In short, every facility should be given to so important an undertaking; and every good vessel be considered eligible.

I have been somewhat minute in stating these matters, as I am very anxious that they should be correctly understood: but there is still a vast deal of detail unmentioned, which, indeed, I could not properly introduce in this work.*

However, before I quit this subject, I would draw attention to one circumstance, of no small importance to our West Indian colonies; which is, that the Chinese, though particularly partial to rice as food, are by no means so wedded to it as the natives of India: on the contrary, a Chinaman will eat anything and everything eatable. In the Straits Settlements Chinese are always found to cultivate yams, cocoas, plantains, bananas, sweet potatoes, &c., in great abundance, and to live very much on them; so that no reasonable doubt can exist that in Jamaica or other parts of the West Indies, the Chinese labourers introduced would, in the course of a short time, in a great measure abandon the constant use of rice, and support themselves on the ground-provisions produced from their own lands. Perhaps the importance of this does not strike the mind at first sight; but, if it be remembered that each man will eat at least one* pound weight of rice a day, costing certainly, in Jamaica, three-halfpence, it will not be difficult to discover that 100,000 persons eating rice will consume, in a year, upwards of 225,000*l.* worth of rice: which money must be taken from the island, to be paid away to the rice-growing countries; whereas, if these emigrants will, as I imagine, content themselves with such provisions as the island itself produces, the country will be saved that annual sum, and, consequently, be much benefited.

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* A pamphlet on this subject will shortly appear, in which the author will give the minutest details on Chinese emigration.

Having now given a sufficiently plain exposition of my plans for the supply of labour to our West India colonies, I may with propriety proceed to notice the cultivation of estates by means of "the hoe:" always premising that the "plough," from the nature of the land, cannot be used. This takes me back to the point (page 76) from whence I digressed; and to which I must beg to refer the reader.

In parts of the country, which are stony and rocky, or very steep, it often occurs that the land is of a very choice description, and that an abundant water-power is available for moving machinery; both which are considered by the planter, as of sufficient importance to outweigh the laborious work which such kind of land entails: hence we see many estates so situated still in cultivation. Independent of the extra amount of labour to wield the hoe, we find that carting canes, manuring lands, depredations by rats, and other disadvantages have to be contended with, which are very expensive and troublesome: but the islands being well supplied with Chinese labourers, I will suppose that these estates can be cultivated with success.

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* A Chinaman, when laboriously employed, will eat 2 lbs. of rice a day easily.

The system to be pursued, then, is to cultivate them by "contract;" which may be of two kinds: viz., by the acre, or by the cwts. of sugar produced by the land. By the former, the Chinese contractors engage (if uncultivated land) to clear off all brushwood, grass, &c., burning the same; to dig the land, plant out canes, and in every way attend on them until they come to maturity; then cut, tie them up in bundles, and lay them on the road or pathside, for the carts or mules to take to the mill; at a certain sum per acre: quite independent of what the produce may amount to. Whilst, by the latter, and in my opinion the best possible system, they receive payment according to the quantity of sugar yielded; no matter what the quantity of land may be. Thus one or two smart enterprising Chinamen will offer to take on contract, say fifty acres of land, to establish in canes, attend to, and when ripe, cut, tie up, and lay on the roadside for conveyance to the mill.

To carry out this, the Chinamen will engage, perhaps, forty* Chinese labourers, and settle them on the land selected—in one house—looking to his employer, for a few dollars in advance to buy basins, saucers, chop-sticks, pails, a couple of large iron boilers, lamps, and other necessaries; also, for food for one month's consumption, and implements, as hoes, &c., so as to establish their "congsee" or company. All this arranged, the men are set to work, and managed by the two contracting Chinamen: but the planter must have their names called over twice a day, to see how many are actually on work. At the end of the month, all the days are added up, then divided by twenty-six, to give the average number per diem, and these are paid for so much for the month according to the rate agreed on. For instance, wages are, we will say, five dollars a month, day labour; then I agree to give my contractors three dollars for every twenty-six days' labour performed on the estate; and they distribute it to their labourers according as they may have worked. I have nothing to do with this part of the business: I reckon twenty-six days' work to one month, and advance to the contractors three dollars for that period, or amount of labour; leaving them to arrange their own accounts with their countrymen, in their own fashion. There is never any difficulty in this; for they are, as a people, perhaps the most minutely correct in accounts, of all others. In this case the contractors feed their men, and keep an exact account of every article supplied them, and also of the work they do each day; so that immediately the planter pays the advance, the contractors call together their men, and apportion it out as it may be due. Thus the planter is relieved of a vast amount of trouble and anxiety, for the contractors keep a sharp look out after their men; and these, again, all combine to carry out the contract, and very vigilantly guard and protect their cane-pieces from harm or depredations whilst growing; and when cut, one (or more) of the "congsee" stays in the mill-yard and boiling-house, to watch the canes until they are crushed, the juice boiled, and the sugar ready for measuring. This takes place, from the coolers, when it is going to be potted; and is accomplished by having a wooden box, which has been proved to hold (by weight) a certain quantity, into which the new sugar is first thrown, then carried off by the potters. The careful Chinaman stands by, lending a willing hand, but marking down every cwt. as it is measured and called off; and when the whole produce of their fifty acres of land is worked off, the number of cwts. of new sugar made is calculated at the sum originally agreed on, and the gross total amount is then subject to the deduction of the various sums of money advanced by the planter to the "congsee," from time to time; after which the balance, whatever it may be, is paid over to the contractors, and that account is thereby settled. But, although the planter has settled his accounts with the contractors, they have still their accounts to arrange and settle amongst themselves, according to the secret understanding always existing between them. During all this time, of course, the young rattoons are being cared for, and dressed, by the same contractors; under, very probably, a new agreement: and so the employers and contractors go on, each, by attending to their own interests, securing the interests of the other. The Chinaman, on the one hand, knowing that he cannot be cheated, but that he will be sure to be paid for every pound of sugar made from his canes; whilst the planter, on the other hand, knows that his property is sedulously watched and protected by many an anxious eye; and that, come what may, he only pays for the quantity of sugar actually made: so that 1 cwt. of sugar in the "cooler" costing him a certain amount, will, when cured and dried, stand him in a sum which he has satisfied himself will either pay a profit or exhibit a loss.

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* When the land is all planted out, and the canes banked, the contractors always reduce their gang: sometimes one-half!

He can make his calculation beforehand with a very near approach to correctness. The responsibilities of the estates are divided amongst many: he does not stand alone, the sole, hoping, dreading, anxious one; but he has on every hand those who share his hopes and fears, and whose vigilance and untiring energies are devoted to ensure a happy result. Thus far advantageous is Chinese contract work; and if the planter will only keep a firm hand with them, and be kind and reasonable, he will always find his work progress in a pleasant manner.

Firmness is one of the most essential qualities, in dealing with Chinese: but this should not degenerate into obstinacy. Kindness, affability, punctuality, and forbearance, are also necessary; but firmness must never for a moment be lost sight of. A planter must be on his guard in this respect; and a short time will suffice to satisfy the Chinaman that his employer is not to be overreached or trifled with.

Whenever a Chinaman takes land to cultivate by contract (per cwt. sugar), the planter must allow him to pursue his own methods: only seeing that he does not commit any serious and palpable errors; and he must also refrain from interfering with the common labourers, giving his orders to the "contractor," alone. If he has any faults to find, and scolding to bestow, he should always be careful to do so out of hearing of the common labourers; so that the position and authority of the contractors may not be lessened in the eyes of their men. As far as regards the mere cultivation details, both the planter and Chinese understand them tolerably well. It is evident that many of the rules laid down as necessary to be followed on estates using the plough, also apply on estates using the hoe; therefore I need not repeat them: but I would observe that the sugar-cane is the same plant in both cases, and consequently requires the same mode of treatment. On many mountain estates, however, the cane-trash cannot be used for manure, for many reasons; therefore, only that portion not required for fuel, and other matter, can be used for manuring the fields. Other differences occur, of which the planter is well aware; and to whom it must be left to make those modifications shown by local experience to be best adapted to the nature of the particular locality.

Previous to dismissing the subject of the cultivation of the sugar-cane in the West Indies by Chinese emigrants, I find that a few brief remarks are necessary in regard to the climate of the West Indies, and its effect on the Chinese constitution. I have heard many (who know nothing of the matter) declare, that Chinese emigrants would speedily fall a prey to the yellow fever in the West Indies, and allege this as the only existing reason against their employment in those colonies. Now, from my own positive experience, and careful observation, I do not hesitate to say, that I do not participate in this fear: indeed, I think that, with the exception of the negro's, no human constitution can so well withstand the effects of the West India climate as the Chinese.

The "frightful mortality" amongst the European troops and emigrants in the West Indies, which has so appalled the English reader, has many explanatory circumstances connected with it, in the first place; and secondly, no reflecting mind can, for an instant, compare the Chinese with the

European constitution: it would be the very excess of absurdity to do so. As well might we suppose that European labourers could supply the place of the hundreds of thousands of Chinese who are working in the fields and swamps of Burmah, Siam, Quedah, Penang, Province Wellesley, Malacca, Singapore, Java, Borneo, Manilla, and other countries; where they are to be seen at all times, from daylight until night, toiling at the most laborious occupations, under the heat of the most scorching sun; and generally in the midst of mud and stagnant water.

Have none of these countries malignant fevers, dysenteries, and other deadly diseases equal to, or surpassing those of the West Indies? Could European labourers abide a week's work in such countries? Certainly not! And I am confident that the Chinese would find the West India Islands as healthy and agreeable as they could desire. I have often thought, whilst looking at a Chinaman working in his grounds in the Straits,* how much I should like to see half a dozen picked negroes working beside the same number of Chinese, with the Chinese chankol (hoe), for one full day; with the thermometer at 90° in the coolest house; and I have as frequently turned away quite convinced in my own mind that no negro could stand it out one whole day: the weight of the chankol alone would break his heart, whilst "John Chinaman" works away like a piece of machinery, apparently without effort and without fatigue. This is no light comparison; and I am satisfied it is a correct one: as the West India planter will find in time to come. I do not think it necessary to add further on the question of the constitutional ability of the Chinese to withstand the climate: a few individual exceptions may certainly occur; but no doubt exists in my mind as to their being admirably adapted to the climate, and the climate to them.

The system of cultivation pursued in Demerara next falls under notice, as being distinct from that usual in the islands, and may be considered as altogether peculiar to that colony.

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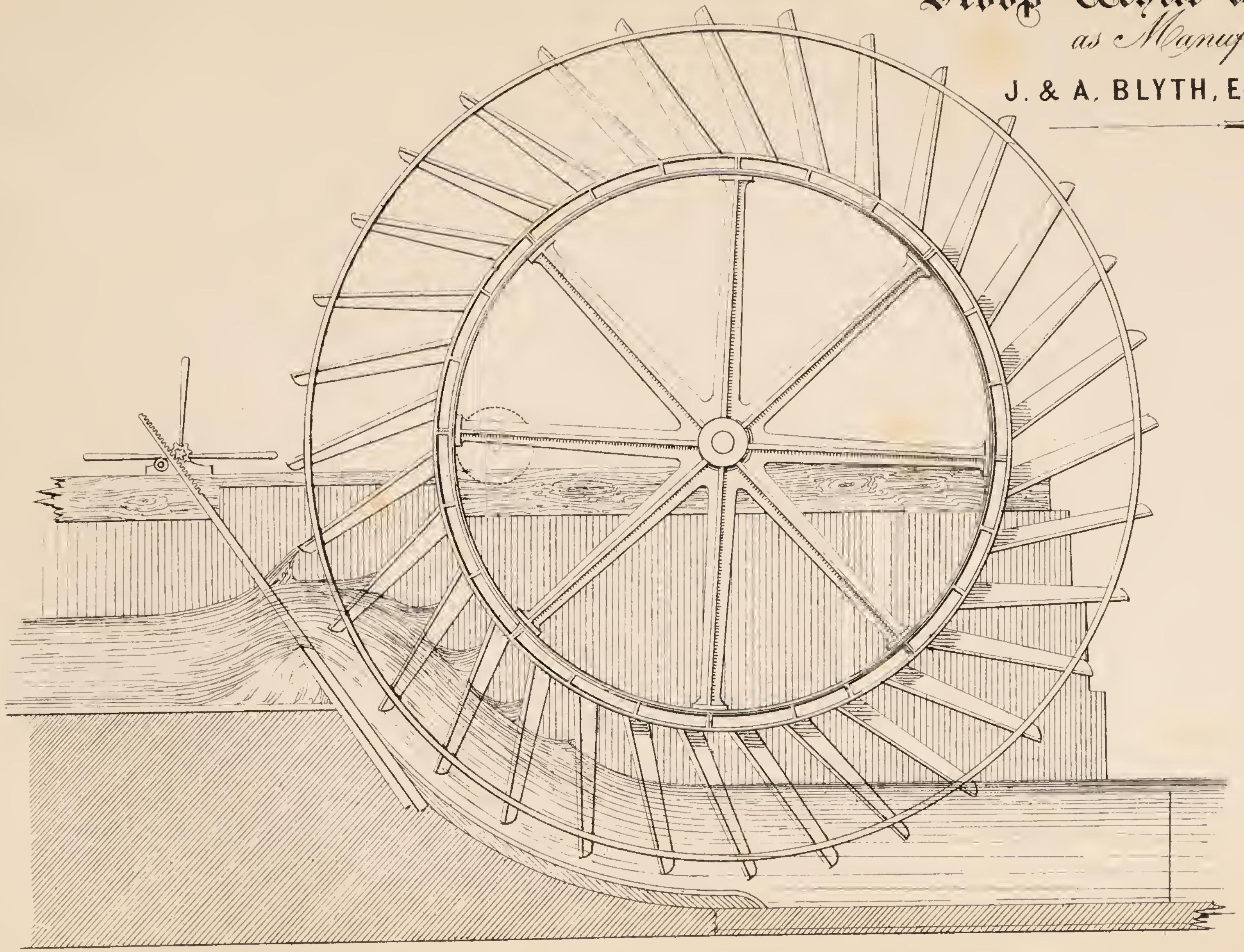
* It must be noticed that a Chinaman, working in his own grounds, or by contract, is quite a different man to what he is when working by the day, for mere wages.

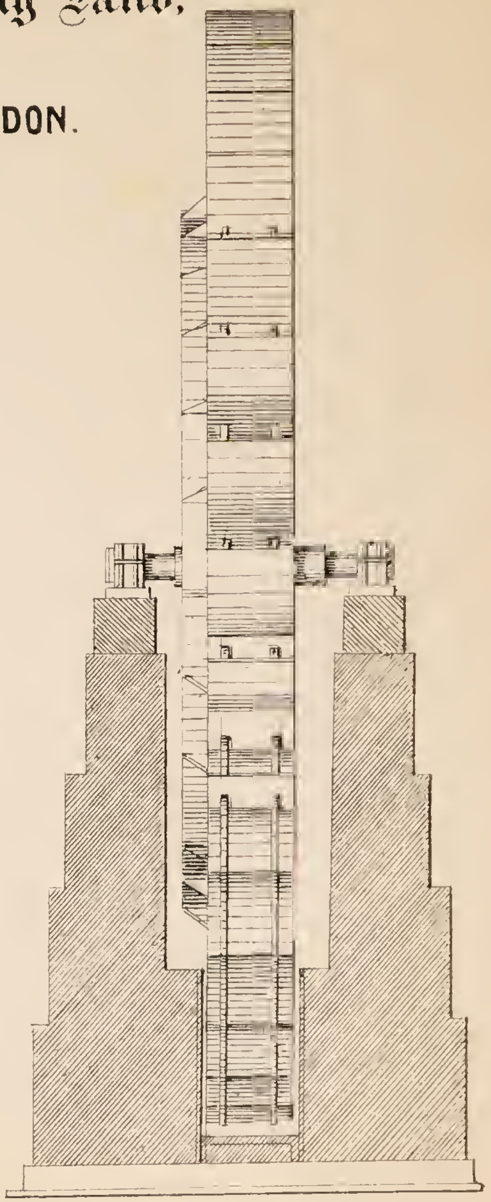
The grand consideration is the construction of canals or drains, and the means to be employed in raising and discharging the superfluous water over the bunds or embankments, which are obliged to be made to keep out the tidal inundations. These three may be considered the essentials to the very existence of a Demerara estate: namely, the strong and expensive embankments, the canals and drains, and the machinery to raise and discharge the water over the banks. The mode of cultivation also is influenced by the nature of the country. The estates are all facing the sea, from which they are protected by strong embankments, having expensively-constructed sluices to let off the water that has accumulated on the estate; but as the land lies so low that it is impossible to use them, except at ebb tides, the planters are obliged to have recourse to numerous mechanical contrivances to secure a complete drainage. Thus, steam-engines, windmills, mules and oxen, are all to be seen actively at work, giving effect to the various draining machines, which have been imported, at great expense, from England. Messrs. Blyth and Co., the engineers of Limehouse, have sent out several very excellently contrived machines for this purpose, drawings of which I have seen; and I have been informed that those proprietors who have been enterprising enough to procure these, and similarly ingenious machines, have found that their estates not only return them an increase of produce sufficiently large to repay the cost and every attendant expense, but an amount over and above, to be applied to the exigencies of the property. We all know the improvement in the quality of sugar that has resulted from the introduction of the vacuum pan and improved methods of evaporation, &c. but few allow the full importance due to the improved system of drainage, as now practised on Demerara estates. In former days, the sugar from this colony was of the most

Scoop Wheel for Draining Land,

as Manufactured by.

J. & A. BLYTH, ENGINEERS, LONDON.





Litho. Waterlow & Sons, 66, London Wall

dark and inferior description, but recently the use of the vacuum pan, and the better drainage of the cane lands, have, together, completely altered its quality and raised its value to a high standard.

The drainage of the land being of such importance, the estates are found intersected with numerous drains and canals running both parallel and at right angles; so that the sugar-canes, when cut, are conveyed to the mill in punts, which traverse the canals and drains in all directions. The planters are also said to have hit on a plan of ploughing their land by the aid of a steam-engine, which is at once simple and effective. The estates are usually about four hundred or five hundred yards in breadth, and from three to five miles in length, with a canal running up the centre, and a smaller canal or drain running parallel with it, on either side of the estate; the engine is then fitted into a boat, which traverses the centre canal and gives motion to the plough by means of an endless chain or rope, attached to a wheel placed in another boat, which last takes up a position in one of the parallel drains or canals, so that the plough is drawn backwards and forwards between the two canals.

As the plough arrives at the extremity of the field, the two boats move on the required distance; then the motion of the engine is reversed and the plough returns: so that by this simple arrangement, the ploughing of an estate is accomplished most expeditiously.

The Demerara planters deserve a very great deal of commendation for what they have already adventured in this; but it is a thousand pities, that whilst they are about it, they do not carry out the principle to the extent to which it is capable. An engine which is placed in a boat for ploughing and preparing land, cleaning canes and other work of similar character, can also (by a very simple contrivance) be made to bring out canes from the cane pieces to the boats in the centre canal; also to clean the different canals and drains, work the draining machine, saw boards for the use of the estate, and, indeed, perform a multitude of services.

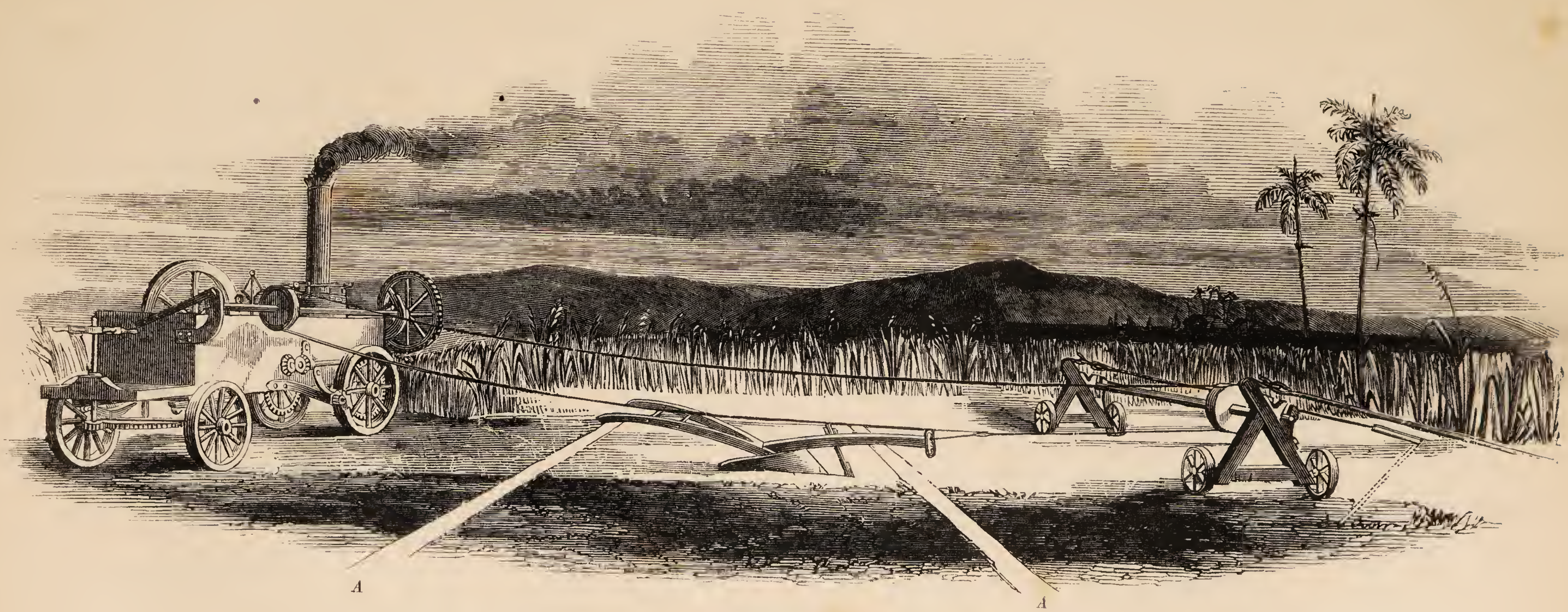
But is it on a Demerara estate *alone* that a "*locomotive steam engine*" can be thus useful? Does it necessarily require a low, marshy estate, where canals can be availed of? Cannot such an engine be most serviceably employed on any tolerably level estate, having roads, and which is not too rocky? There certainly is no earthly reason why a locomotive-auxiliary-engine should not be used; on the contrary, every possible argument is in favour of it.

I have purposely abstained from mentioning this most valuable and desirable assistant before, for to the Demerara planter decidedly belongs the credit of having commenced its use (although but partially); and I therefore allowed the subject to remain unnoticed, until entering upon the Demerara system of plantership.

I was first led to the investigation of this subject, from seeing the great difficulty of ploughing the low swampy lands in Province Wellesley; where after a couple of days' rain, the plough buffaloes very often could not move a step without sinking up to their bellies into the soil; so that it was absolutely necessary, to allow a few days' sun to harden the land again, before they could return to work. Now such a delay as this, could not but be distressing; and it made me revolve in my mind the possibility of working the plough to advantage by steam. Thus was I led on, until the full advantages to be derived from the possession and employment of a locomotive auxiliary steam-engine became quite apparent to my mind.

There are a very great number of estates in Jamaica, and the other West India Islands, on which such an auxiliary can be used to very great advantage; in Bengal, and in the Straits settlements, every estate should have one: and no doubt will, by-and-by. What the planter would desire to avail himself of, is the great power, unwearying labour, and nice precision of the steam-engine: in the performance of such work as he would require of it, he would not wish for

PLATE II.



LOCOMOTIVE STEAM ENGINE AND ITS ASSISTANT.

NOTE.—A A are two spaces, intended to represent *breaks*.

speed; either when stationary or when moving about the estate. However, this will be more intelligible after I have enumerated the chief labours which the auxiliary engines may be expected to perform. These comprise:—

1. Ploughing cane lands in every way.
2. Harrowing and *haingherring*, until well pulverized.
3. Ploughing trenches, six feet apart, for cane-tops.
4. Cleaning, moulding, and first-banking young canes.
5. Bringing out canes from the field, to carts or waggons in the road.
6. Drawing cane carts or waggons to the mill, and returning with green trash.
7. Distributing the green trash throughout a recently cut field.
8. Levelling banks and covering up cane trash, &c. &c.
9. Bringing manure carts to the fields, and distributing the same.
10. Bringing sand (if required) to the fields, and distributing the same.
11. Sanding the roads and rolling them, whenever required.
12. Pumping water for irrigation, when necessary.
13. Draining land, whenever required.
14. Drawing carts with produce to the wharf, and returning with coals, &c.
15. Sawing up timber into boards, and planing the same.

Besides many minor performances from time to time arising.

I am well aware that this enumeration is quite enough to make an old jog-trot planter go crazy with genuine indignation and surprise; but plain sober truths are not to be denied: they will not only gain a hearing, but eventually will triumph over everything. However, a few explanations may serve to render somewhat more clear, that which I have but simply stated.

It is quite evident, that if an engine can be fitted up in a boat, and floated off from one end of a property to another, it can also be made on a carriage fitted with wheels, so as to convey itself along the roads to any part of an estate; not being required to race along the roads, but merely to move along slowly. Arrived at the field, which (we 'll say) is to be ploughed, it first drops its "*assistant*" (if I may so call the carriage which supports the wheel or "drum," over which the endless band or chain works) in the road, at the point where the ploughing is to commence, then runs round to the opposite point, in the *other* road parallel to it, and takes up its own position; having the field between them. The engine and its "*assistant*," being now placed directly opposite each other, the ploughman and engineer adjust the endless band-chain or rope, over the drum wheels, placing the *supports* or braces of each, firmly against the ground; they then lift the plough from off the engine and place it in its required position in the field, attach it to the endless chain, and finally throw the carriage wheels *out* of "*gearing*," and the shaft of the *drum into* "gearing." The ploughman then proceeds with his plough to the opposite side of the field, the implement being drawn by the endless chain; the engineer thereon reverses the motion of the engine, without altering the position of the drum, if the plough be required to return in the same furrow, as in trenching for cane holes; but in close ploughing, the drum wheels of both engine and its assistant, are moved on their shafts the desired distance (by means of cogs or teeth, or a screw, if preferred); and the engine being started, the plough (single or double* furrow) returns to the other end of the field. When the drum wheels have travelled the full extent of their shafts, the engine and assistant are moved on, just their own length, and the ploughing continues as before; and so on until the field is finished.†

In preparing land; in cleaning, moulding, and banking canes; in bringing out canes from the field to the road; in distributing green trash, manure, &c. to the field; and in levelling banks and covering up cane trash, the engine and its assistant would occupy the same relative positions: only the work would of course vary to suit the particular operation desired. For instance, in bringing canes from out of the field to the carts in the road: the endless band has, in this case, bundles of canes hooked on to it by a peculiar and very simple arrangement; and as it travels slowly onward, carries the bundles to the engine; on arriving near which, they are successively struck off, and fall on another small "*traveller band*," which carries them on to the waggons immediately behind the engine.

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* With steam-power, a double-furrow-plough could always be used, in moderately light land: and would perform double the work of a single plough.

† In such work as this, the engine should have a good covering to protect it.

Thus, from the time the endless band is set in motion, until the waggons are loaded, there is no stoppage; but the band travels slowly onward—the cane tyers hitching on their bundles as they get them ready—so that the delivery is constant. When the waggons are all loaded with cane, the engineer stops the machinery, disengages the *band*, throws the drum shaft *out* of gearing, and the engine wheels *into* gearing; then attaches the engine to the waggons and proceeds with them to the mill-house, where they discharge their canes, and return laden with green trash to the field. Arrived at its original position, the engine again receives the endless band, by means of which the green trash is sent throughout the field; wherein men and boys are stationed, at regular distances, to strike off the bundles in rotation. Immediately the waggons are emptied, the men hurry back to their cane-tying, leaving the boys to distribute the trash along the trenches; the engine and assistant then move on a few paces to a fresh position, and recommence the operation of bringing out canes and loading the waggons. In this manner the endless band moves on over the whole field, bringing out the canes, and returning the green trash as it proceeds. To expedite the work, and render it more easy, it would be desirable to have a number of cane ties or bands, (which are nothing more than pieces of half-inch rope about three feet long, and tarred, with iron hooks or rings at each end) for tying the small bundles of canes (tied with cane leaves) together into large bundles, for transmission by the endless band to the waggons. Some of the same kind, but longer, would be very useful for tying up the cane trash, as it comes from the mill; so that the waggons might take it in bundles to the field, and pass it along at once without trouble or detention. Sand, and manure of all kinds also, could thus be more cheaply brought and distributed over the land than by any other method.

It must be observed that, in carting canes to the mill, or manure, &c. &c. to the fields, the state of the roads must be bad indeed, to offer an objection to the use of the engine as a moving power; for it having broad wheels, and going at a slow pace, the roads would not be cut up into ruts, neither would the machinery of the engine be injured by jolting about. In fact, no carts or oxen would require to traverse the roads of the estate; consequently, whatever ruts were made, would be by the engine and its waggons alone: but with such a powerful and active labourer (as this locomotive at command), what could possibly excuse bad roads? They could be hoed, sanded, and rolled at any time by the power of the engine itself, when not more particularly engaged; and, consequently, should be kept in the best possible order. The public roads which the engine would have to traverse in conveying produce to the wharf, may in some cases be far from good, but, as before said, the pace need not be a fast one: on the contrary, it may be quite slow, so as not to jolt the machinery too much. In a great number of instances, the estate may be situated on the banks of a river, or may have a communication by a creek; in which case there would exist no necessity for the produce being sent off the property in carts or waggons. Again, there are many estates so situated with regard to the shipping port, that a steam-engine could not be used for sending down the produce, or bringing back supplies of coal, &c. Nevertheless, I think that eight estates out of ten, on which the plough can be altogether used, will be found to be so situated that the locomotive engine can be employed in such work: but even if a few cattle were obliged to be kept for this purpose, it would not be of much consequence.

In draining land, as in Demerara, the engine would always be useful; for after being engaged in a variety of tasks during the day, as night advances, it could be floated off to the draining machine, and made to work that during the night; returning in the morning, once more, to its daily task.

In irrigating lands, as in India, it could be made of great utility, by raising water, whenever not otherwise employed; and also during the night, if any large tanks are on the property, these being filled during the night could be drawn off during the following day for irrigating; or irrigation could take place during every moonlight night: as lands are even ploughed, very often, in India, during the night, in the months of April, May, and June.

Sawing and planing up boards for the use of the estate, is certainly not amongst the least useful of its labours, especially where timber can be procured in quantities, as in India, the Straits Settlements, and some parts of the West Indies; although such work involves the purchase of a circular saw (which is cheap and sufficiently efficient) and a planing machine, (American patent is the best), which is also simple and cheap. Having said so much in favour of the employment of a "locomotive auxiliary steam-engine," it only remains to add, that the requisite power I conceive to be from six to ten horse, and the cost from 250*l.* to 500*l.* for one of the best description.

The idea of a locomotive engine of the character described, occurred (as I said before) to me in the course of my operations as a planter; and the necessity for such a valuable substitute for cattle power, forced itself on my mind, long before I heard that such a suggestion had been thrown out by a person of the name of "Whitty." I have since, however, understood that that gentleman, once proposed something of the kind: but if my memory serves me right, his plan also embraced the crushing of the canes by the same engine; which, as a locomotive, was to be used in ploughing lands, in carting home canes, and in all other work. However, I heard no detail whatever of his plans, but merely the very slightest mention of his having suggested such a thing; all the details that I have given, are therefore purely my own conceptions, which, after considerable study, I have carefully arranged even to the most minute particulars.

In returning from this long digression, to the Demerara system of plantership, I would wish to observe, in respect to the non-practice of trashing and the manner in which the cane is allowed to run along the ground, that, to these two errors is attributable in a great measure the very poor quality of their cane-juice.* The first is certainly a very great error, and the second is no less so; and these are the more open to censure, inasmuch as they can be remedied at a cost, that will be abundantly repaid in the increased quantity and superior quality of the sugar yielded by the canes.

The trashing required, is a very simple operation and not an expensive one, whilst the benefit derived from it has been already fully shewn. Why, then, should the Demerara planter defer using such an obvious means of enhancing the richness of his cane-juice? In regard to the cane falling over and running along the ground, the remedy certainly is more expensive; but by the aid of the plough, and the engine in the boat, the difficulty is readily overcome; for the canes can be banked up as they grow, once, twice, and thrice, until the banks have attained a sufficient height; when the canes (being well supported at the roots) will no longer fall over: or at least very partially. It may happen that after the last banking, a few labourers may be required to dress up the banks neatly and firmly; which they can do very expeditiously with their hoes or spades.

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* My information on these points rests altogether on the testimony of others: I shall be concerned and disappointed to find that I have been misinformed.

Whatever expense is incurred in these operations, cannot be placed in comparison with the advantages gained: but to render this system still more beneficial, the canes should be planted in rows at least six feet apart, and the land should be thoroughly drained; by attending to all which, fields that now yield cane juice averaging only from six to seven degrees, by the saccharometer, would then furnish juice indicating from eight to eleven degrees: which, in a crop, would make an enormous difference in favour of an estate.

An enterprising French gentleman, in the Straits, tried on one or two of his fields, (low, marshy ground) the Demerara plan of non-trashing and non-banking; and had in consequence the canes falling over and running along the ground to extreme lengths. At fifteen months old, when he cut them, their juice only averaged five degrees by the saccharometer: this effectually disgusted him with the Demerara plan; so that he afterwards allowed his Chinese to pursue their old course of banking and trashing, as practised on the other fields of his estate.

If the scheme of Chinese immigration be carried out as I have suggested, the Chinese will speedily exhibit the good effects of their system on the Demerara estates; and I think, of all others, their mode of culture is the best adapted to that colony. Some Chinese emigrants, if I mistake not, were once imported into Trinidad from Singapore or Pinang, and according to all accounts, they did not answer so well as was anticipated; in the Mauritius also, the same disappointment, I believe, was experienced. But during my residence in Penang and Singapore, I was repeatedly told that the very sweepings of the Straits had been shipped to those colonies: vagabonds so notorious in Singapore, Penang, and Malacca, (not to speak of the Dutch settlements) that the chance of shipping them off to a distant country, was hailed as the most fortunate occurrence by the inhabitants of those settlements; whilst the rogues themselves were glad to emigrate: first, in the hope of reaping a rich harvest in the country to which they were going; and secondly, because their multiplied offences in the Straits, had rendered those settlements too hot for them. Thus the planters of Trinidad and the Mauritius, instead of obtaining a number of honest, sober, and industrious labourers, had let loose on them a band of villains and "jail-birds."

I was once talking to a gentleman owning large property in the Straits, of Chinese emigration to the West Indies, when he said,—"Well, if they want any more Chinese emigrants, I hope they will send here again for them; for the *last time*, we made a complete clearance of all the rogues and vagabonds in the place: but now, from the Dutch sending their Chinese convicts to Singapore, and other reasons, thieves and gang-robbers are accumulating very fast in the Straits; so that a few shipments again to Trinidad, the Mauritius, or Jamaica, would be just the very thing for us. We would manage to ship them off quick enough."

After this, I should be much surprised had the planters of those colonies been pleased with such emigrants: indeed, it is to be expected that the impression caused by such a wholesale importation of *scamps* must be very unfavourable to the Chinese character; and no doubt the recollection of their misdeeds must be both vivid and exceedingly disagreeable. Still, it is but just to make every allowance for the difference which must exist betwixt bad men and good men, of whatever nation or class they may be; and although there undoubtedly might have been amongst them, some few, who when shipped were good men, fresh from China; yet, as the majority were bad, the contamination necessarily spread.

As the Straits Settlements are but of very recent standing as sugar-growing colonies, and as very little is generally known of them, I will state a few circumstances relative to the tenure of land and other matters, which may be interesting. In Province Wellesley the planters purchase their land direct from the East India Company, at the rate of five rupees (about ten shillings) an acre; which then becomes freehold property. In Malacca the lands are either granted at a low quit-rent, or leased at one rupee (two shillings) an acre per annum. In Singapore no fixed arrangement has yet been arrived at; but, in the meantime, a certain yearly rent is levied on all land occupied by Europeans, at least.

As to the Chinese cultivators in the country, they seem to do much as they please: cultivating land as long as no rent is demanded from them, but abandoning it immediately it is; and betaking themselves to another patch of new land, to go over the same trick when called on for rent. There is only one sugar estate in the island of Penang itself; but on the opposite shore of Province Wellesley, there were, in May last, thirteen estates (and two projected) belonging to Europeans, and upwards of 1000 acres in canes belonging to different Chinese.

Some of these estates have as much as 500 acres each, in cane; they are cultivated by Chinese on the contract system, and have all excellent steam-engines, improved evaporators, concentrators (one has a vacuum pan), and copper stills. In Malacca, there are no sugar estates yet established by Europeans; although large tracts of land have recently been granted for that purpose by the local government (subject to the approval of the Bengal Government) to a French and a Hanoverian gentleman, who are to have the land free of rent for five years, and afterwards at *sixpence* an acre, as long as the British retain possession of Malacca.

In Singapore, there are two estates; one having 200 and the other 300 acres, planted out in canes: the former having a steam-engine, and the latter an undershot water-wheel. On the whole, then, there are sixteen working estates (and four others being established) in the Straits Settlements, besides abundance of waste land admirably adapted for sugar estates, both in Malacca* and Singapore; awaiting the selection of the capitalist and planter.

* All the *eligible* cane lands in Penang and Province Wellesley are already occupied.

The lands whereon the sugar-cane is cultivated in Province Wellesley, lie low, and are, until well drained, very marshy and swampy. Hence the necessity of making drains and canals; the labour and expense of which are, under the contract system, pretty equally divided between the planter and his Chinese contractors, as will be seen.

When a planter purchases a piece of land, he gets a kind of rude plan of it from the official in the land-office; after which he goes round the boundaries with compass, chain, and rod (erecting, where necessary, blocks of granite as boundary-marks), and measures the whole; making a map or plan of his own, to serve him until the Government Surveyor can be sent to make a correct survey.

Chinese then flock in, offering to cultivate certain portions of the land, according to the established rates; which results in contracts being entered into, of generally from twenty-five to fifty orlongs* to each congsee.† The following contract will serve to give a good general idea of most contracts, at this moment existing in Province Wellesley:—

We, Leong Appong and Lim Allowee, Chinese sugar-cane cultivators, do hereby agree and contract with Mr. James Smith, of Hope Estate, Province Wellesley, as follows, viz.:—

That we will take fifty orlongs of waste land on Hope Estate, when measured out for us, and will cut, clear, and burn, all jungle now growing thereon,‡ digging up all grasses, roots, and stumps, and thoroughly burning the same.

That we will dig the said land with the hoe (as is usual), and plant it out with canes, in rows, at regular distances of six feet asunder; supply the same, when required; and, in short, mould, clean, bank, trash, and in every respect take care of the said canes until they arrive at maturity; then cut the same (when ordered), tie them up in convenient bundles, and lay them on the roadside, or put them into the canal-boats, for conveyance to the mill.

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* An orlong is about 240 feet square, or about one and a third acre.

† Congsee signifies a firm, a company, a partnership: it is usually pronounced Koongsee.

‡ Not heavy tree or forest jungle, of course.

That we will dig all drains and cross-drains, required on our said fifty orlongs of land, throwing up the earth on one side (if so ordered), to form roads; and will keep these drains clean.

That we will employ, and forthwith place on the above work, fifty able-bodied Chinese labourers, keeping the full number constantly employed until the whole fifty orlongs of land are planted out in canes, and the plants have received their second banking,* when we shall be at liberty to discharge twenty-five men, keeping the remaining twenty-five of their number still employed on the estate.

That we will receive and obey all orders given to us by Mr. James Smith or his representative, in regard to the execution of this engagement.

That to enable us to carry out this our agreement, Mr. James Smith shall advance to us the sum of two hundred and fifty dollars ($ 250), with which we will purchase hoes and other necessary implements, build a good and substantial house for our labourers, and lay in a stock of provisions, furniture, cooking utensils, &c. &c.

That Mr. Smith shall advance us, monthly, four dollars† for each man, working full thirty days; to ascertain which, the estate's native assistant shall call over the names of all our men, at work, both morning and afternoon.

That when the canes produced on our said land are manufactured, the new sugar in the cooler shall be weighed in our presence, and for each picul of such new sugar yielded by them, Mr. James Smith shall pay us one dollar and a quarter ($ 1¼), after deducting the above-mentioned advances, together with all others, that we may receive from him.

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* "Banking" signifies to give the cane plants a bank, by heaping earth round them to support the roots, and keep the plants from falling over.

† The advance monthly is now only three dollars each man for thirty full days.

That all the accounts shall be made up and finally adjusted within one month after our canes are manufactured.

I, James Smith, do approve of, and agree to, the above contract, and hereby bind myself to carry out my part of the agreement, and make the necessary advances; on the understanding that the above conditions are well and truly performed.

(Signed) James Smith.
(Signed) Leong Appong.
(Signed) Lim Allowee.

Province Wellesley, January, A. D. 184—.

(Signed) ——— } Witnesses.
(Signed) ———

Immediately the contracts are made, the planter lines off his different roads and drains, and contracts for the digging of the main drains or canals, at the rate, generally, of ten cubic feet for one cent.* of a dollar; which is the price I have myself paid repeatedly.

All the lesser drains and cross drains appertaining to the different allotments, are dug by the contracting cultivators themselves; and lead directly into the main drains or canals, which carry off the water. In forming roads, therefore, the planter incurs very little cost; as the contracting cultivators usually dig a small drain (of about four feet wide) on each side of the space marked out for a road, throwing the earth into that space, where it remains until it has become dry. Thus far the cultivators assist, but now the planter has to lay out the earth, carefully and evenly, to form his road (which he does by contract); and afterwards a little sand, judiciously applied, serves to render it sufficiently firm and hard for ordinary purposes.

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* About equal to a halfpenny.

When the contract cultivators have land ready for planting, they look to their employer to supply them with cane-tops; which he is thereon obliged to purchase in the neighbourhood, at an average price of about one dollar a thousand, deliverable on the estate. These are, of course, choice or picked tops, which will rarely fail, if planted carefully. The Chinese are very fond of planting two tops together, using in this manner from seven to eight thousand cane tops to each orlong of land ; whereas, with choice tops (in good land) planted in lines six feet* apart, four thousand are quite sufficient: *id est*, allowing only one top instead of two. I am, however, inclined to calculate five dollars as a fair average sum per orlong for plant tops; and this cost has to be borne by the planter himself. In the course of a short time, cane tops for planting will be much more cheap : as hitherto there have been numerous purchasers, in the planters settling new estates.

Sluice gates are provided and fixed in their appropriate places, and their working is consigned to the care of appointed persons. Very frequently the contract cultivators nearest the spot undertake this charge.

Beyond these enumerated items, a planter has no further expense, as far as the cultivation is concerned ; and the only trouble necessary is, in seeing that the several contractors maintain at work the requisite number of labourers, and that they perform their contracts in a proper manner. For the latter purpose, occasional personal inspection, aided by the constant attention of a native assistant, is quite sufficient; and the planter has therefore abundant time on his hands to attend to the erection of his manufactory, and the manufacture of his crop when ripe.

In this manner estates are cleared and brought into cultivation in the most regular, systematic, and satisfactory manner possible; and where the nature of the land permits, the cane pieces are laid out in squares of equal sizes, being divided by roads and drains, running parallel to, and at right angles with each other. The "works" are always situated in a carefully selected spot, as central as possible; having regard to other important requirements, such as water carriage, fresh water, fire wood, salubrity, &c. &c.

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* In Province Wellesley cane rows are often seven and even eight feet apart, but only in rich forest land newly cleared.

The settlements of Province Wellesley, Malacca, and Singapore, are peculiarly favoured in respect to these latter advantages; to which may be added a very fair fertility of soil, and a cheap and abundant supply of food of all kinds.

Under so many favourable circumstances, it may readily be conjectured that sugar can be produced very cheaply; which indeed is the case: but it has not yet been ascertained what the planter (of these settlements) can really afford to supply it at. To explain this, it is necessary to observe that the cane is cultivated altogether by hand labour: the hoe (*chankol*) is the prevailing implement; the plough has as yet been only used in partial experiments.

As an exception to this, I must particularise the estate of an enterprising American gentleman, in Singapore, whereon the plough has been certainly very much used. With this exception, my assertion strictly applies; and, as may be supposed, the employment of human labour is consequently a direct and heavy tax on the produce of an estate. The planters undoubtedly have it in their power to change the system; although I am well aware the Chinese would at first oppose it strenuously: but this is a difficulty of very slight importance, and only requires firmness and perseverance to overcome it entirely. Hitherto every excuse may be allowed, inasmuch as three-fourths of the estates at present under cultivation, are but newly established; and consequently, but partially freed from the roots and stumps which cumber the soil, and render ploughing difficult, and in many cases impossible. But wherever the land has been under cane culture one or two years, these impediments (in nine cases out of ten) no longer exist; and then, a planter not insisting on the use of the plough, may very justly be taxed with exceeding folly and weakness.

As will be noticed, the contracts current in the Province Wellesley, expressly stipulate for the entire removal and destruction of all roots and stumps of trees and bushes; and wherever the planter keeps a strict eye on his contractors, this stipulation is faithfully performed: so that after the first crop is taken off, the plough and other agricultural instruments may safely be used.

Hundreds of active young elephants can be procured in the Straits at from 50 to 100 dollars each; admirably suited for estates' work, of various kinds, but more especially for ploughing. One of these animals will close plough a full acre of land during the day, with the greatest ease to himself; and only requires to be attended by his keeper in addition to the ploughman. To perform similar work (*id. est.* chankoling an acre of land) requires at least fifty Chinese labourers—which is a fact admitting of no denial. Is it not evident, therefore, that we cannot hope for a knowledge of the lowest price at which sugar can be produced in these settlements, until the plough is brought into general operation? Any one visiting Singapore, may see a small elephant named "Rajah," working daily on the estate of J. Balestier, Esq. (the American Consul); and although the animal is only five years and a half old, he will plough his acre of land a day with all ease: I have repeatedly walked up and down the furrow with him, and been delighted with his performance. One man holds the plough, and another (the keeper) walks beside the animal, and directs him in his duty. The docile little creature obeys every word that is said to him, and (although, no doubt, sorely tempted) will plough all day between the cane rows, without plucking a single cane. I am positive, that a less number than fifty Chinese labourers could not dig up the same quantity of land that I have repeatedly seen this little elephant plough in a day. But independent of elephants, buffaloes and cattle abound in the Straits, costing not more than 10 dollars each on an average. These animals, if properly fed and tended, are excellent for ploughing and other estates' purposes.

But above all other power, a small auxiliary locomotive engine is that which is best suited to the wants of the planter in these settlements. With it, he could plough up his lands, pulverise the soil, and in short perform all the descriptions of work specified at page 117; except conveying produce to the shipping port: which indeed is not required, as water carriage is so complete, and so much more advantageous. An engine of this kind, is pre-eminently adapted to estates circumstanced as are those of Province Wellesley, Malacca and Singapore: in consequence of the vast supply of hard-wood for fuel; the low, marshy nature of the lands, whereon canes are usually cultivated; the liability to loss by death of elephants, buffaloes, and bullocks; not to mention the immense economy of labour, &c. &c., in every department. I cannot therefore sufficiently recommend this locomotive to the attention of the Straits' planter. But apart from the particular motive power to be applied to the plough, and other agricultural implements, let us merely instance an estate in these settlements, having all its cleared lands cultivated by the several mechanical contrivances, now available, instead of by the inefficient and expensive hoe; and the following are a few of the facts, which, we will find, present themselves.

At the present moment, the established wages of a Chinese labourer is *three dollars* a month throughout the three settlements. In Singapore, on the estate of Dr. Montgomerie, the contracts with Chinese are very similar in all respects to that shown at pages 123, 124; but with this most material difference: viz., that the contractors are only allowed an advance of TWO DOLLARS a month for each labourer actually working, instead of *four dollars*, which has been the prevailing rate of advance in Province Wellesley until very lately. Now, with the wages of labourers (such as the powerful, enduring, and intelligent Chinese), at *three* dollars a month, sugar can be produced very cheaply; even though the cultivation be carried on by means of the hoe and manual labour alone. But if we apply this cheap labour in connection with improved machinery in the *cultivation*, and scientific apparatus in the *manufacture* of the sugar cane, how much more cheaply can sugar be produced! According to present practice, a Chinese contractor, engaging to cultivate land that has already produced canes, employs on fifty orlongs (about sixty-seven acres) twenty-five to thirty labourers, constantly; and usually agrees to receive *one dollar* for each picul of granulated sugar produced by such land whilst in his hands, as a full and final payment. But were this contractor to employ a couple of young and active elephants, or ten good buffaloes (costing respectively, say—the former 150 dollars the latter 100 dollars), he would require, if elephants, four men; but if buffaloes, eight men, to work them. This would therefore enable him to cultivate fifty orlongs (sixty-seven acres), with fourteen men and two elephants; keeping two ploughs (or other implements) constantly at work, if required, and ten men. Whenever the elephants were not working, three of their men could be in the field assisting the others, and the remaining *one* man would remain to attend to the feeding of the animals. Thus, ten men would always be available for planting, thrashing, and other purposes; and occasionally thirteen. In this manner, although a contractor paid his labourers an average rate of four dollars each a month, during fifteen months he would only expend on this score 840 dollars; add to which, food for elephants, 200 dollars, establishment of congsee, 60 dollars, fair profit to contractor, on 50 orlongs cultivated, say, at six dollars an orlong=300 dollars: and we find the total expense of the cultivation and cutting of the canes to amount to 1300 dollars, or twenty-six dollars an orlong. From this land, we may fairly estimate forty piculs of undrained sugar per orlong, or 2000 piculs from the fifty orlongs; and if paid for at the rate of sixty-five cents of a dollar, amounts, as nearly as possible, to the 1300 dollars: which has been shown to afford a handsome profit to the contractor.

It is safe to calculate the difference between dry, marketable sugar, and the undrained sugar alluded to, at *one-third;* although in Province Wellesley, where the planters have excellent "*evaporators*," and concentrate their syrup on the "*low temperature*" principle, the drainage of molasses, and loss in drying, do not amount to so much. Assuming, however, *one-third*, we find that 2000 piculs, undrained, yields 1334 piculs of *dry*, marketable sugar; which will not lose an ounce weight on the voyage to England. This, then, costs the planter about one dollar a picul (four shillings and fourpence), or three shillings and sevenpence three farthings per cwt.—for the mere cultivation, not reckoning the molasses. This latter may be calculated at one-fifth, or 400 piculs; which, with the feculencies from "*boilers*," will yield 4000 gallons of over-proof spirit, worth on the property (at the lowest), thirty-five cents a gallon—equal to 1400 dollars.

It is obvious that I have allowed a full time for the planting and working off of the crop, whilst I have made but a low average return produce; which certainly should be much higher, considering the excellent preparation and working up the soil would receive. Land well worked up and with its cane-trash returned to it, will yield two tons of fair Muscovado sugar per acre, even with the machinery and boiling apparatus now used in the Straits. Besides this, the returns (in the Straits) should never vary; as no portion of the leaves or trash of the cane should ever be applied to any other purpose than that of manuring the lands, and thereby keeping up a constant and increasing fertility.

It is not usual in the Straits settlements for estates to grow further than, 1st, rattoons on their land, as it is found preferable to plant every second crop; consequently, in cultivating with the hoe alone, the contractor employs on fifty orlongs about thirty labourers at first, until the whole of the land has been turned up, planted out, and the plants received their second bank: all which will certainly occupy ten months or more. When the canes are thus far advanced, he will discharge five of his men; retaining twenty-five to continue the cultivation and cut in the crop. This period may be reckoned at eight months; but very frequently it will be ten: however, to compute the whole time at eighteen months—

We have 30 men 10 months, at 4 dols. each, a month....	1,200 dols,
„ 25 „ 8 „ „ „ „	800 „
Establishment of Congsee, advanced	100 „
Cost of cultivation. Total....	2,100 „
2,000 piculs of raw sugar yielded, at 1 dol. per picul....	2,000 „
Showing a loss to the Contractor of....	100 „

which leaves the contractor to make a profit, if he can, out of the labourers whom he employs. This he can easily do, as he feeds them all, and gives them a balance in money; by which arrangement the singular management of the Chinese is brought to bear, and the contractor thereby not only obtains his own food and that of his writer, free, but also contrives to pocket a few dollars. Few indeed they may be; and in this case, a deficiency of one hundred dollars would go nigh to absorb the whole: but still his speculative and enterprising spirit would lead him on, as long as there remained a prospect of even a very small gain.

I have estimated, in both cases, the price of labour to be four dollars each man per month; but lately, as I have before noticed, this rate has been reduced to three dollars a month: at which it now is, and will, in all probability, continue.

This difference makes a considerable alteration in the position and profits of the contractors; but I have never yet known an instance of the planter getting them to accept a contract under one dollar a picul. However, the planter may arrange this matter with his contractors. It is very evident that, in contrasting the two modes of cultivation, viz. that by the plough, and that by the hoe, the reduction in the rate of wages would influence both (very nearly) in proportion to the number of labourers employed in each. A difference would undoubtedly be made in the payment of the ploughmen and the keepers of the elephants, of about one dollar each a month; so that whereas common labourers would receive but three dollars, these would earn four dollars a month: or perhaps, in peculiar cases, even more; which would make them careful in the performance of their work, and cautious how they lost such remunerative situations. Were buffaloes to be used instead of elephants, there would be an extra number of men required to work them; but the difference would be met in the item "food," (for which I have allowed two hundred dollars) required by the elephants.

I consider elephants of small size preferable to buffaloes, on a sugar estate in the Straits; and have no doubt that one will do more work, and be in every way more serviceable, than five buffaloes. In ploughing, the elephant applies his weight to the draught in a peculiar and extraordinary manner; maintaining a constant and very steady pull, instead of that quick, jerking motion so frequently attributed to him. They are better able to stand the heat of the sun than buffaloes; and I do not think them nearly so susceptible of disease, for with ordinary care they have been known to perform unabated service during upwards of fifty years.*

Be this, however, as it may, and supposing the planter to choose between the locomotive steam-engine, the elephant, the buffalo, and the bullock, as his prejudices or his necessities may influence him; still, the culture of the cane by means of the plough and other implements *must* supersede that by the hoe.

Another point which the Straits planter will do well to direct his most serious attention to, is that of returning to the soil the green trash and green and dry leaves of the cane, instead of using one portion as fuel, another as fodder, and burning the other on the field, as at present practised. It is well known in the Straits that the Chinese prefer taking on contract the cultivation of jungle and waste land, rather than that which has been cleared and already produced canes some years. But why is this, unless it be that land, after producing a crop of canes, is entirely stripped: first, by the canes being sent to the mill, from whence no part returns; secondly, by the green tops being removed to the cattle-pen, for fodder; and lastly, by the dry trash or leaves remaining on the field being burnt off, according to Chinese practice. This stripping for a few crops (and no manure), as a natural consequence, impoverishes the soil; and the Chinese contractor says, "Give me jungle land to cultivate: I do not like this land; it entails much work, but affords no profit." Thereon the planter takes up another patch of jungle land, and abandons that which has been cleared and already cultivated. Now, were the Straits Settlements unprovided with wood for fuel, we might adduce that, as a reason for not using steam, for the purposes of evaporation and concentration; but the very reverse is the case: wood of the best description is to be had in any quantity; thousands of the best wood-cutters in the world are at hand, anxious to supply estates with wood, deliverable on the properties, at the very lowest possible rate; a vast and incredible quantity of excellent fuel is actually under the planter's very nose, and yet he persists in robbing his cane fields of their natural and unequalled manure, to provide fuel to boil his sugar with! Nor is this all: for we may next consider the actual cost of the cane-trash to the estate; which is, with very few exceptions, very high, in consequence of the prevalence of showers. On some estates all work is often stopped for many days together, because the cane trash is not dry: constant showers during the day render it unadvisable to risk the trash outside the trash houses; consequently the dry trash on hand, is quickly used, and there being no longer any fuel, the mill is stopped, and the manufacture suspended.

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* In Upper India (amongst the natives) they have been known to work eighty years.

In Province Wellesley there are certainly spells of dry weather, during which this exceeding inconvenience is not felt; but at other times I have known long spells of wet weather happening at the very time when the crop was pressing hardest on the planter. Often from fifty to eighty acres of canes are fit to cut, and even a portion spoiling, when rain sets in, (sometimes heavy and sometimes only in tantalizing showers) and effectually prevents the cane-trash being dried; consequently the mill must be stopped, however disastrous the delay may be. Sometimes the planter keeps a number of men working near the mill yard, on purpose to house the trash in case of a sudden shower: a bright sun is shining, of which he takes advantage to spread out his trash: a cloud threatens, and in a moment all hands are called; a few drops fall, and the cloud passes off: it is a false alarm, and the people retire to their employments. Again another cloud, and another gathering, only to disperse as before, for the cloud has passed; but once again it threatens, a few drops fall, all hands are called in haste; they run from every point, but, alas! too late: every sugar boiler, every domestic, even, is pressed into service, but all in vain: the rain comes down in torrents, and in a few moments the trash is as thoroughly soaked, as if it had been steeped in a pond. As a few days' sun are required to repair this mischief, the mill stops, the cane cutters are put to other work, the manufacture is suspended, and injury in many respects is done to the estate. In this manner the crop is retarded, and exceedingly prejudiced.

Every estate in the Straits presents similar scenes; which are, too, of constant occurrence: yet none have adopted the simple remedy of boiling by steam. A vast supply of the cheapest fuel is at hand to boil the cane juice; the sugar produced would be superior both in quantity and quality; the green-trash would be returned to the soil as manure: which would serve to keep up a constant fertility, under which latter condition the Chinese contractors would at all times prefer the cultivation of such land, to clearing and establishing jungle lands; add to all these, that the cultivation could be conducted on this system far cheaper than on any other.

If the Straits planter will only avail himself of the several suggestions herein made, there can be no doubt, that he can produce sugar at a rate as cheap as (if not cheaper than) any planter in the world. To operate against him, he has only the difference of freight; which may be taken at 2*l.* per ton, in comparison with that of the West Indies. This gives 2*s.* per cwt. which certainly is not a very large sum, considering the many advantages enjoyed by the Straits' planter; although when we come to reckon against slave grown sugar, this item tells heavily: for instance, every estate producing 500 tons of sugar, pays 1000*l.* extra, before its produce can reach the English market; independent of the proper cost of cultivation and manufacture. However, even with this additional burthen, I do not fear for the well doing of any estate in the Straits, on which the practice I have here advised be followed.

There is yet another description of contract which has been partially tried, but which I have never known to produce any satisfactory results; this is the contract by the orlong. But I must divide this kind of contract into two classes: the first, being in every respect similar to that by the picul, except in the mode of compensation; which is (according to the nature of the land) from 40 to 55 dollars for each orlong of cane, brought to maturity, cut, and laid in bundles by the roadside, independent altogether of the quantity of sugar it may yield; whilst the second is what may be termed price, or job work. For instance, the contractor undertakes to clear the land, dig it, plant it with canes, supply and give the young plants a first banking; taking every care of them until they have reached the height of about three feet; when he gives up charge of them and receives the sum per orlong, stipulated for: generally from 20 to 25 dollars. Then, when requiring cleaning, &c., the same cane pieces are again given out, (perhaps to the same contractors) to clean, bank twice, trash, and take care of, until arrived at maturity; then to cut, tie up in bundles, and lay on the road side, at from 25 to 35 dollars an orlong.

Some planters have even tried this latter contract, in parts; giving out the land in certain portions, to clean, bank, trash, and cut the canes, as separate jobs; as those operations were successively required: but I believe no good has resulted from such description of contracts.

Wherever the interest of the cultivator is not directly implicated, the planter has no assurance of his cordial co-operation; there is an absence of that fellowship, which so greatly relieves the planter's anxious mind, and is so necessary to success: that fellowship created by a common interest, a mutual risk, and a mutual hope of profit.

Thus the contractor finishes his job, and his men leave the field, quite indifferent whether it be destroyed by fire, eaten down by wild elephants, robbed by human prowlers, or in any other way injured, an hour afterwards. Indeed if they were to see bundles of canes being cut and taken away, they would not consider themselves called on to act as policemen to the estate, or even to volunteer information against the robbers—not they. But under contracts by the picul, woe betide the unlucky quadruped, or biped, caught trespassing by the contractor or his people.

But so it is all over the world: interest rules with the Chinaman, as well as with Englishmen; but perhaps John Chinaman carries the principle further than most other people: however, in this particular case, it is a feeling which tends very much to the benefit of the planter, and it certainly is his own fault, if he do not take advantage of it.

Having given these details of the contracts prevailing in the Straits, I will now briefly notice the manner in which the Chinese pursue the cultivation of the cane.

Of course the first process is clearing off the jungle, and burning it when dry; then they proceed to chankol (hoe dig) the land, digging up all stumps and roots of trees and bushes as they go along, piling these up in large heaps, and generally covering them over with clods of earth and clay; so that when the heaps are set on fire, they burn gradually, furnishing a rich store of ashes, charcoal, burnt earth, and burnt clay, to scatter over the land and enrich it. The drains and small cross drains are now supposed to be dug, and the land ready for planting.

Two long lines and a couple of sticks, measuring six feet (or seven, if desired) each, are taken to the field, and the lines being laid down six feet apart, the Chinamen slightly loosen the soil along the line; then the hoe is struck into the ground to some depth, the handle pressed down so as to open the soil, and two cane-top-plants are inserted. The hoe being withdrawn, the earth closes on the plants, and about a couple of inches only of each are seen protruding above the ground. About twenty inches to two feet further on, other two tops are in the same manner inserted; and so on all along the line, which is moved on from time to time, until the field is planted out. I must remark here, that this method is most wasteful and pernicious; as, in wet weather, from one-third to two-thirds of the tops so planted are rotted, and their place of course requires to be "*supplied;*" which entails an expenditure of both labour and tops. It is only in the very driest weather that such a mode of planting can succeed properly; but, in fact, I object to it in toto, for I have always found that tops so buried in the earth (especially in strong clay soils) could never throw out the shoots which in other cases would have sprung from the "*eyes*" of the lower joints. If reference be made to Figure 1, Plate I, it will be seen that each joint has an "*eye*" or bud, which, under ordinary circumstances, will burst forth into a plant; but it is evident that, if the cane top be thrust down into a heavy soil, and has a mass of cold wet clay pressing on it, the lower joints so circumstanced, instead of being able to produce their shoots, will die away; so that, at the best, shoots can only be expected to spring from the upper joints: if, indeed, the plant be not altogether killed. It is generally much the best plan to leave the cane tops altogether uncovered, merely placing them regularly along the rows, at equal distances; in which case almost every "eye" shoots forth vigorously.

When the young plants are about twelve or fifteen inches high, a light moulding can, with great propriety, be given them; whereon they will progress rapidly, and throw out numerous off-shoots from their newly formed joints, as shown in Figure 2, Plate I. By adopting this system of planting, a saving is effected of fully one-half the number of "tops," besides the economy of labour in "supplying." This method is peculiarly adapted to the Straits Settlements, where showers, (and even heavy rains) are so frequent: but it is of course evident, that whenever a period of very dry weather occurs, cane tops planted during its continuance, should be protected, by having a covering of earth given them. This is, however, an exception to that which I consider should be a general rule; and no planter should allow a cane top to be covered over, unless it be during a season of very dry weather. Coupled to this, however, is a caution which I have found to be highly necessary, viz. that when the young plants have attained the height of about twelve inches growth, a light moulding must be given them, otherwise they become burnt, and are completely thrown back: indeed so completely, that they themselves never become other than puny canes; whereas, those that are timeously moulded, continue growing, bold and vigorously, and become fine, large-sized canes.

Another serious fault in the Chinese is their sometimes trashing canes too high; thus depriving the cane plant of those leaves which are essential to the perfection of the joints to which they belong. The planter should particularly impress on his Chinese contractors the very great importance of sparing those leaves which are still green and unfaded. I have often seen canes bleeding, as it is termed, profusely, from having the leaves of their upper, and still imperfect joints, forcibly stripped off; and have remonstrated with the Chinese for so doing: but the only reason they could give, was, that it saved them the trouble of returning to retrash the field, within a given time. It certainly is true, that if they are permitted to strip off leaves, which if left, would continue to supply nutriment to the plant for some two or three weeks longer, they thereby save themselves the trouble of returning at the end of that time to take off those leaves, then dry; but the amount of injury done to the canes is very far beyond the amount of labour saved: it is, therefore, a most injurious economy.

The next point to which I would call the attention of the planter, is also of great importance; and the obstinacy with which the practice is persisted in, only calls for the more vigorous interposition of his authority among his contractors. This is the most pernicious custom the Chinese have of cutting their canes fully twelve, and often fifteen inches under ground; which they effect by digging down into the high banks (raised to support the canes) and thus exposing a considerable part of the lower portion of the cane-stalk, which has been for months under ground and thrown out roots. This they do that they may lose nothing available in the cane; and the same reason prompts them to allow as little as they possibly can of the cane, in cutting off the "plant tops:" thus we see canes sent to the mill often with from twelve to fifteen inches of the lower end, worm eaten and quite acid, from being so long underground; and from four to ten inches of the upper end quite white and soft, from being unripe. This last mentioned portion should have been allowed to form part of the "cane-top plant;" but the Chinese, in their greediness, stint the top, that they may gain a little more juice from the cane. But this juice will yield no sugar; although it will cause considerable injury to the other portions of the juice, give an immense deal of trouble in the boiling, and finally produce a quantity of molasses in the curing house. All this injury, trouble, and loss, fall on the planter; he suffers in every way, and, after all, has to pay for the undrained sugar made, (as it comes from the coolers) molasses and all: which is precisely the object held in view by the wily contractor. But this need not be: every planter can avoid it, if he will only be careful to specify his objection to it in his contract, and stipulate for its practice being abandoned. Nothing more than this is necessary.

In concluding my remarks on sugar cultivation in the

Straits Settlements, I must once more impress on the planters the very urgent necessity they are under of attending to the several matters I have endeavoured to direct their attention to. They certainly are most happily situated, in regard to fertility of soil; complete water carriage; drainage; the supply of excellent fuel; freedom from import and export duties; a fine, seasonable, and healthy climate; and lastly, an abundant supply of the cheapest and best labourers in the world. All these extraordinary advantages they decidedly possess, as well as many others; but still it is necessary that they take every precaution to insure successful cultivation in time to come. Slave-grown sugar is to be admitted on equal terms with our own, into the British markets; and it therefore behoves the Straits' planter, as well as the West Indian, to correct at once those errors now existing, and steadily pursue that course which reason points out. He has it in his power to effect a very great improvement, both in the agricultural and manufacturing departments; by the which, he can produce sugar at one-half the price it now costs him. The former I have pointed out to him, and in a succeeding chapter I will endeavour to make it equally clear as regards the latter. Let the Straits' planter take courage; let him be true to himself, and firm in his determination to carry out the requisite improvements; and I do not imagine he has any cause to fear even the entire withdrawal of the present protective duty.

In treating of the cultivation of the sugar cane in Bengal, it is necessary to divide the subject into two parts, viz.: that as pursued by the natives; and that practised by the Europeans, who have established estates in that country. It must also be borne in mind, that the country is so vast, and the climate in many parts so various, that differences will be found to exist in the practice of the natives, and the quality of the canes grown; but in all the districts ranging from Allahabad down to Calcutta, (including Allahabad, Benares, Jaunpore, Azimghur, Ghazeepore, Goruckpore, Patna, Monghyr, Burdwan, and many others) the remarks that I am about making, apply. If we reckon only 100,000,000 as the amount of our Indian population (which is certainly much under the actual number) and even estimate the consumption of sugar at not more than one lb. a month for each person on an average, still we find that this will give the enormous amount of 535,714 tons of sugar per annum; which is quite independent of the immense quantities exported to neighbouring states, and to Europe.

But to any one conversant with the habits and customs of the natives of India, it will be at once evident that they consume much more than double the quantity assumed; perhaps treble: not all in the form of sugar, but as sugar, molasses, and sweetmeats; which, however, all proceed from the same plant, and serve to show how extensive must be the cultivation of the cane in India. Of this vast quantity, that produced by European enterprise is an utterly insignificant portion, in comparison: I will therefore commence by speaking of the native modes of cultivation.

A few natives may be found here and there, who have, to please an European neighbour, cultivated a few roots, or even small patches of the Otaheite, and other superior descriptions of cane; but with these very rare exceptions, the various kinds of country canes are universally cultivated. It has already been stated at pages 8, 9, 10, that the native or country canes are numerous in variety, and inferior in quality; but those common about Calcutta are infinitely superior to the wretched things, called canes, which are cultivated in Upper Bengal. These latter differ also from each other; and this, coupled with the difference of soil, mode of cultivation, and degree of attention bestowed, produces a striking variation in the quantity of raw sugar obtained per acre. Thus I have known the range to extend from eight maunds (640 lbs.) to thirty maunds (2,400 lbs.) of "goor," (raw sugar in its roughest state) per acre; and I believe fifteen maunds of such goor to be, at present, a very general average per acre. This "goor" is generally sold in the native markets up the country, at about 2½ to 3 rupees a maund: the acre yielding at this rate, say 4*l.* 10*s.*; which will be seen to give but a scanty return for the labour, time, and trouble bestowed on its cultivation and manufacture. The cultivation of the cane by the native is a very simple affair, yet it entails on him a considerable deal of trouble: as will be apparent from the following detail of the process. February, March, and April are the months during which the native usually plants his sugar cane. The land is first prepared by ploughing and haingheriug, until the soil is quite pulverised, and its surface very evenly smoothed over. It must not, however, be supposed that the instrument designated "a plough," bears the slightest similitude to our English implement of the same name; on the contrary, it is quite different: however, such as it is, the native manages to scratch his land with it to his entire satisfaction, by making numerous journeyings, hither and thither, over his land. Four "chasses" is the least a field can be reckoned to receive before the haingher is put to work: thus, close ploughing from east to west, from one end of the field to the other, is termed one "chass;" from north to south in same manner, another "chass;" then from north-east to south-west and from north-west to south-east two other chasses. These make up the four chasses, by which time the surface of the soil is tolerably well scratched; the haingher is then set to work, and soon crushes all small lumps or clods, and reduces the surface to a perfectly smooth state. Sometimes the soil being very hard, their ploughs will not enter the ground; then the chankol (hoe) is had recourse to, and the land is dug in large clumps; some time after which, the plough is used, until by dint of constant turning about, the clumps or clods are so far broken up, as to allow of the haingher being employed to advantage. If the native be an industrious man, and time allows, he will perhaps turn up his land several times before he plants it; and he will also treat it to a little manure in the shape of a few baskets of ashes: but it is very seldom that cow dung is used, in consequence of the scarcity of wood for fuel; as a substitute for which it is universally used.

The land then being prepared, the native again puts in his plough to open small trenches for the reception of the cane plants.

To effect this more successfully, he ties to the plough some bunches of grass to act as a kind of mould board; by means of which he manages to open a furrow sufficiently wide to suit his wishes. These furrows are ploughed quite close together without any regard to regularity; and women and children (generally), following the plough, drop the pieces of cane, as they go along, into the furrow. The haingher is then set to work with all speed (before the sun can dry up the little moisture exposed by the plough), and in a few minutes the field is levelled and completely smoothed over; so that not a vestige of the cane, planted, can be seen. A shower of rain presents a favourable opportunity for planting cane in February; but in March, April, May, and during half of June, not a drop of rain can be expected: cane therefore planted during either of these months, must be irrigated immediately; and even be kept alive by one, two, or more subsequent irrigations, until the rains set in about the middle of June.

In Upper India, " the hot winds" set in usually in March or the early part of April, scorching up everything until the commencement of the rains; hence all canes planted from January to June, must be irrigated several times. April is an excellent month for planting, and is much liked by the natives, as it saves them the labour of two irrigations and several hoeings.

Cane planted in this month may pretty generally be estimated to cost as follows, per pucka beegah:—*

Preparing and planting,	rupees	4
Three irrigations at 1½ rupees,	"	4½
Twelve hoeings at six annas each,	"	4½
Rent per annum,	"	4
Total rupees,		17

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* One pucka beegah, is about two-thirds of an English acre.

This expenditure serves to bring the cane to maturity; which will be in the November or December following, or seven or eight months.

Sometimes, however, the rental of the land is very much higher, for instance, from five to ten rupees instead of four. The above is, however, a very fair general estimate; although it must not be supposed that the poor native really expends one farthing in actual coin, if he can help it.

It must be taken as the value of the labour that he bestows on it, to which may be added many little items, as will be seen. If he be so poor as to have no oxen of his own, then he obtains the use of a pair, for the different operations required, and pays their owner perhaps in grain or labour, or perhaps by allotting him a portion of the crop when manufactured. To assist him in hoeing, watering, and watching his field, he employs his wife and family, or associates himself with some neighbour, to whom, in requital, he probably allows a share in the produce; in which manner, when his crop is manufactured, very little comes to him as his own share, the poor creature being content if the cultivation has afforded him employment for a portion of his time. The other portions of his time he manages to fill up by pursuing various employments, the nature of which very much depend on the particular caste he may belong to. Thus we find natives cultivating their fields, and a few days after (often the next day) we see them busily engaged in some trade or other, or carrying a palanquin, fishing, or some other occupation, which brings them in a few pence; and that alone enables them to bear up against oppressive rents, grinding usurers, low markets, and other ills which very numerously beset them. The very inferior descriptions of cane usually planted by them, together with their primitive and very dirty mode of manufacture, renders the cultivation of the sugar-cane far from lucrative; and the chance of inducing them to adopt a better description is, I fear, almost hopeless.

India has many enemies to the cane plant which are unknown elsewhere; as white-ants, jackals, wild pigs, wild elephants, and hot winds, all which are very serious obstacles to its culture; to which we may add, an item of expense highly important, viz., the high rate charged for conveying produce from the upper districts, by boat, to Calcutta.

I cannot understand how the natives of India can produce sugar cheaper than they do at present, so long as they persist in planting the common native cane, and manufacturing it in the manner they do.

But were it possible to introduce a feeling of competition and genuine enterprise amongst the native cultivators, and thereby get them to adopt a more grateful variety of cane, and a cleaner and more thrifty mode of manufacture, no doubt can exist as to the extremely cheap price at which sugar of good quality could be produced in India.

But another very serious difficulty is to be found in the grasping character of the Zemindars, or native landholders, and the Mahajuns or native merchants; the former of whom would immediately raise rents to the very highest pitch the proverbial patience of their tenants would allow of: and the latter would still continue to practice their cruel extortions, whereby the unfortunate native cultivators are reduced to the merest pittance for the support of themselves and families. In fact, the majority of ryots (native cultivators) are at this moment only the slaves of the Zemindars and the Mahajuns; who fatten on their labour, and keep them hopelessly enthralled.

The cultivation of the cane in India by Europeans is an important subject, in consequence of the immense extension to which it is capable; and the very ill success which has hitherto attended most of the attempts that have been made.

The districts where European manufactories have been established are Tirhoot, Goruckpore, Jaunpore, &c.; but the former may be considered the great focus of enterprise in this respect: I wish I could say that success had characterised its progress; but very recent accounts declare otherwise.

The chief causes militating against this cultivation in India are: first, the land usually selected being unsuitable; second, the extraordinary ravages committed by insects and wild animals; third, the want of a proper system of manuring and irrigation; fourth, the cane generally cultivated being the common native, instead of the more choice descriptions; and, lastly, the peculiar habits and prejudices of the native labourers. By experience I well know how extremely destructive the white ant is: indeed few can imagine the fearful ravages they commit. To guard against them, I have always recommended the cultivation of those lands which, from lying low, are subject to be inundated every year by the overflowing of the various rivers; but it must be understood that these lands are to be selected, a little removed from the banks of the rivers,* and a good bund wall (of about six feet high and six feet broad) constructed so as to enclose them, and entirely keep out the water caused by the inundations. It is well known that there is an immense abundance of such land in every district, and also that the natives are very often in the habit of constructing such bunds around their gardens and mango topes.

The cost of such a bund wall, properly made and covered, would be about 1,000 rupees a mile, or 4,000 rupees for four miles; which would serve to enclose 640 acres of land, and render it eligible for cane cultivation. These low lying lands, being liable to be inundated by water spreading over the country from the overflow of the rivers, are for the most part entirely free from white ants; which could not exist where water would be liable to swamp their underground residences; they therefore infest the higher lands, where they are not subject to this visitation.

It also happens that the low lands are generally of a more fertile description than the higher, and much more retentive of moisture; which are great recommendations.

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* In India the rivers overflow their banks, and their water gradually spreads itself over the country for miles and there remains until the river falls again. It spreads so gradually that the bund walls are in no danger of being washed away; not in the least.

The securing of such land by the construction of bunds, is in the power of any planter meditating sugar operations in India; and it offers him a means of escaping the ravages of the white ant, which is the most important enemy to the Otaheite cane in India that I know of. Elephants also would very rarely attempt to pass the bund wall, especially if a small elephant ditch were dug round the wall; which would be no expense, as the earth would serve to construct the bund.

In regard to the establishment of a proper system of manuring and irrigation, nothing can be more necessary, and nothing more easy. East India planters have by this time, I imagine, discovered that the soil of Bengal is not so fertile as to yield large crops of cane, without manure; and if they have fortunately got over the old idea, nothing can remain to prevent their adopting a rational system of manuring. I need not say, that although the native mode of irrigating land is in one sense cheap, yet, placed in comparison with what European machinery can effect, we must pronounce it tedious and expensive. However, these subjects will be more fully discussed when we come to treat on manures and irrigation.

Amongst the different varieties of cane enumerated in the foregoing part of this work, the planter can have no difficulty in selecting those which are most desirable for cultivation in India; and the Company's Botanic Garden at Calcutta containing most of them, affords a ready means of obtaining a supply. The Otaheite and Salangore varieties, as also the Chinese, appear to be the best for the Bengal planter; and it is only necessary that he use proper precautions, to secure to himself the large returns yielded by these choice canes.

The habits and prejudices of the natives, the planter must study and endeavour to soften down, if he would succeed with them. I well know the difficulties they oppose to him at every step; but I also know that by adroit management they can be made to do many things, which at first sight seem impossible. I think it would be well to stimulate them to exertion, by allowing them to participate in the proceeds of cultivation, instead of restricting them to mere wages at the lowest rate, at which they can possibly afford to cultivate.

This subject leads me to notice the usual application of labour as practised on sugar estates in Bengal, and the comparative advantages of "Ryottee" and "Neez" cultivation. By "Ryottee" or "Assameèwar" cultivation, is understood that cultivation by contract, with the Assameès or Ryots, which is common on indigo factories and sugar estates. Sometimes the land may belong to the Ryot himself, or it may happen that he has it provided for him by his European employer; in either case, however, the planter advances the Ryot a sum sufficient to purchase cane-cuttings for planting, and from time to time supplies him with a few rupees as maintenance, until the crop is fit to cut. These agreements are very various indeed: one of a peculiar character I will mention, viz., that which fixes a price on the canes by arbitration. For instance, when the canes are ripe, the Ryot comes forward and states the fact, whereon the planter names two natives on his part, who meet other two on behalf of the Ryot, and together they inspect the field of cane, and adjudge its value per beegah.

That being thus arrived at, the planter sends men to cut the canes, and carts to convey them to the mill, paying the Ryot according to the price adjudged, after deducting the advances made to him. This plan has some strong reasons to recommend it, although I have known it to press hardly on the poor cultivator, at times. Another, amongst the many, is to agree with the Ryot to plough, plant, irrigate, clean, and otherwise attend to a field, until the canes are ripe, at a set sum per beegah. In this case, it is necessary to stipulate for a given number of ploughings, hoeings, irrigations, trashings, &c. &c. according to circumstances, allowing a fair remuneration for those operations.

But I think it would be far preferable to allow the Ryot a certain sum per beegah (to be determined by valuation if considered advisable), and a per centage on every maund of sugar produced over and above the valuation fixed on; or to pay him according to the number of maunds altogether produced by his land, in the same manner that the Chinese are paid in the Straits Settlements. This point being once fairly understood by the ryots, and confidence established, it remains for the planter to ride, every now and then, over his cultivation, in order to insure attention, and detect any attempts at shirking on the part of the Assameës or ryots.

I am inclined to accord especial favour to ryottee cultivation, as it saves an infinity of trouble, is not so expensive as "neez" cultivation, is more sure and much better guarded.

Besides which, I am convinced, that in all cases, ryots can, by a little dexterous management, be brought to use any improved plough* (provided it is like their old implement, and does not strain their cattle), and plant any description of grain provided for them. As to planting the cane in lines at regular distances apart, and trashing the same when required, they would not for a moment object to it.

The "ryottee" system also causes a great saving in the number of cattle and carts, otherwise requisite on an estate, as the ryots use their own bullocks in ploughing and irrigating, and are always willing to cart home the canes, at a fair rate per beegah. A whole tribe of lallahs, korindahs, peons, chokedars, &c. are also got rid of, and altogether the business of the estate proceeds in the most quiet and satisfactory manner.

That cultivation, which in India is termed "Neez," signifies that which is carried on by hired labourers, under the immediate direction of the planter himself and his superintendents.

To pursue this system, the planter must keep up a number of cattle, and superintendents of all grades; he must issue all orders himself, and look sharply after his people, to see that they are executed; and he must endeavour to obtain from his labourers something like a return for the wages he pays them. It has numerous anxieties, vexations, and expenses attendant on it, from which the ryottee system is in a great degree free. It has, however, some important points which sometimes influence planters in following it in preference to the ryottee. These consist chiefly in being able to introduce any improvements the planter may desire on his estate, without being opposed by native prejudices; and thus being able to pursue any particular mode of cultivation he may wish. In cases where the natives will not enter into reasonable contracts, of course the planter has no alternative but to pursue a neez cultivation. When, from whatever cause, this system is in practice, the native labourers present themselves at daylight for employment; then the lallah (native writer) takes down their names, and the various peons or peādahs select their men and march them off to work. Thus the peon, who overlooks the ploughmen, picks out his men directly their names are written down, and takes them away to the cattle pen, where they catch their cattle, take up their ploughs and away to the field. As long as they are at work, the peon stays with them, and is answerable to his master for its proper performance; and in the evening he sees that the ploughs are all placed in safety, and the cattle delivered over to the proper herdsman.

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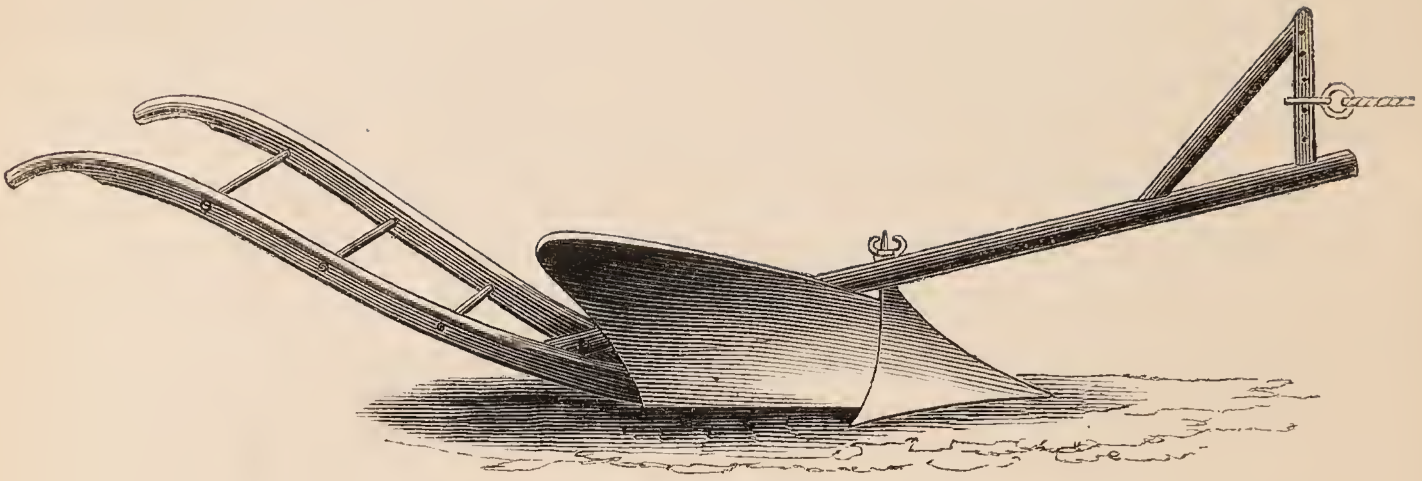
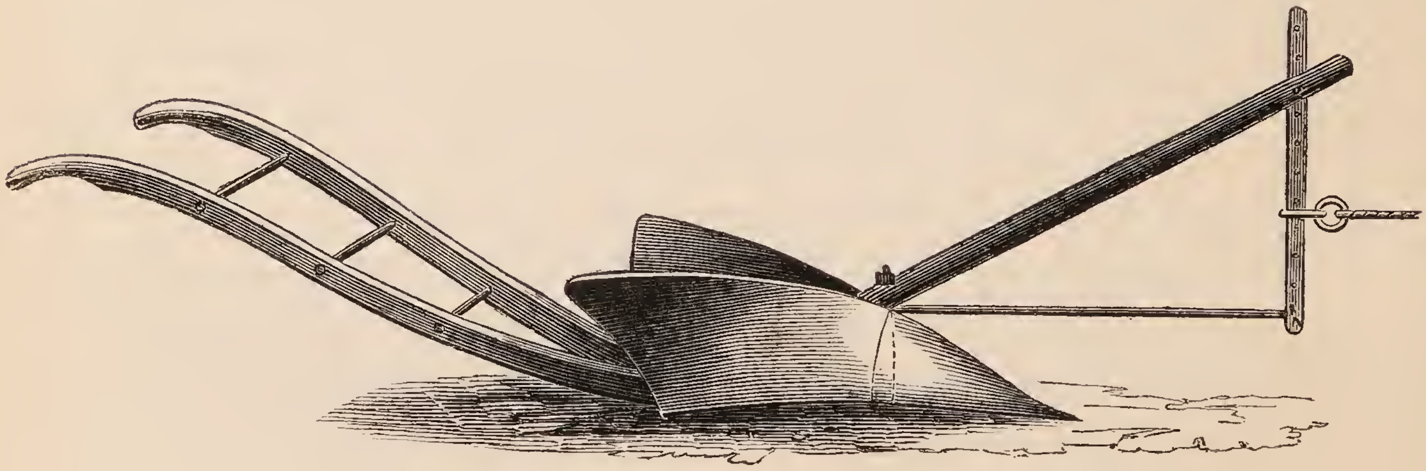
* I never could get the natives to use their own bullocks in the improved American plough, as they said that it strained them; which, however, was only prejudice

In the same manner, the other peons select and accompany their men to the particular work to which they have been ordered; for the proper performance of which they are held responsible. The lallah also visits them twice a day to see that they are all correctly down in his list; and the planter himself or his assistant, likewise counts each gang over, when he visits them, so as to hold the lallah and peon in check. In dividing the different labourers into gangs, respect is always had to the caste to which they severally belong, so that no violence is offered to their religious prejudices.

PLATE III.



(Figure 1.) SINGLE BANKING PLOUGH.



(Figure 2.) DOUBLE BANKING PLOUGH.

With these few remarks on ryottee and neez cultivation, I will now proceed to the details of cultivation as recommended to the Bengal planter.

The land from which a planter can choose is of two kinds; that obtained by grant from the East India Company; or that obtained from the zemindars. In the former case the planter can cut and carve as he likes, it being his own land; but in the generality of cases, such land is mostly in jungle, requiring to be cut and stumped before a plough can work, or a cane be planted. In the latter, however, the lands are "village lands," which, in all probability, have been in cultivation for centuries.

To arrange with the natives, however, for the rental of these lands, is no easy matter; although a becoming *douceur* to the chief zemindar, very generally accomplishes the matter. This difficult point being once arranged, everything that follows is comparatively simple, as the lands are quite clean and fit for immediate preparation. One great fault of zemindaree land for Otaheite cane cultivation, is the great necessity there exists for manuring it; and the difficulty of procuring sufficient manure to supply a large quantity of land at once. Under such circumstances, no better means can be adopted than ploughing up the soil thoroughly, to a considerable depth; thereby bringing to the surface some of the subsoil: which is a performance that certainly cannot be expected from the native plough. To effect this, the small wooden plough shown in Plate III. Figure 1, may be used to great advantage.* I have before alluded to this useful little implement at page 65, and it now becomes necessary to give some further account of it.

In 1841, "The Agri-Horticultural Society of India" presented me with a small wooden plough, which they denominated "an American cotton plough," and I speedily put it to work (in one of the upper districts of India) in order to test its suitableness for sugar-cane culture.

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* Figure 2 (same plate) is a double banking plough very excellent for trenching; when made to follow No. 1. it throws up the earth on both sides very neatly.

As I did not find it work so well as I desired, I altered it by degrees, until I brought it to its present state; when I gave it the name of "the improved American plough." I not only worked with it myself, but also supplied it to many of my planter friends who applied to me for it; and, indeed, I may say, that it is now very generally known throughout India. I have ploughed and trenched with it some three or four hundred acres of land for sugar cane; I can therefore safely recommend it for its simplicity, efficiency, and practical utility. It requires only one man and a boy and two cattle to work it; as the soil is so light and so easily worked. The man puts it on his shoulder and walks off to the field with it, the boy following with the cattle; and they work from half-past five to half-past nine o'clock, A.M.; and again from three to six o'clock, P.M. During the mid-day interval of five hours and a half rest, the cattle get each one seer of gram and a naud of boosah;* then are allowed to graze for a couple of hours, so that in the afternoon they go to their work quite fresh. The cattle I used in India were of two kinds, viz., the Tirhoot, hornless, lop-eared breed; and the common country bullock, with horns; both kinds costing about sixteen rupees (1*l.* 12*s.*) a head. I found by allowing them each one seer (2 lbs.) of gram (a kind of pea) a day, together with as much boosah as they could eat, and giving them a couple of hours grazing in the day, and good dry stabling at night, that they would close plough one beegah† a day, or trench for canes (at four feet apart) two beegahs in the same time. This work they would perform continuously without showing any symptom of fatigue: on the contrary, they improved exceedingly in condition and strength. I allowed my land two chasses and one thorough hainghering before it was ploughed into trenches for the reception of cane plants.

The time occupied in these three operations, was three days and a half to two beegahs, at a cost of about one rupee per beegah, at the following rate:—wages of ploughman and boy together, three annas (about 4½*d.*)* a day; gram, two annas (3*d.*) a day; allow for bullocks, four annas a day; in all, nine annas (1*s.* 1½*d.*) a day.

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* Chaff.

† A beegah, two-thirds of an acre.

The West India planter will be greatly astonished to learn that in Bengal, land can be ploughed twice, well pulverized, and neatly trenched for cane, at about two shillings and sevenpence per acre; yet so it is, and a further statement may not be unacceptable, in regard to the cost of the plough and cattle. The former can be made on the property at an expense of not more than five rupees each, iron work included; and very excellent young cattle can be procured in any number, admirably adapted to this work, at from ten to twenty rupees each; making the whole out-turn to cost about thirty-five rupees (3*l.* 10*s*). No one, whether European or native, who has seen the work performed by this plough, will for an instant hesitate in saying that one "chass" with it, is more than equal to twenty "chasses" with the common native implement: such then is "the improved American plough."

With the common native plough, the planter can have four chasses to the beegah for one rupee by contract work; in which case, the ploughman finds his own plough and bullocks: but the careless manner in which it is executed, combined with the mere scratching which the land can at best obtain by it, renders it a very undesirable and unsuitable implement for cane cultivation. I would wish to impress on the Bengal sugar planter the strong necessity there exists for a thorough turning up of the soil; which certainly cannot be effected by the native plough. I would urge on him the beneficial results always attendant on deep ploughing in India; and the expediency of bringing to the surface a goodly portion of the sub-soil. The small plough now under notice will accomplish this, and at the same time by no means strain or injure the cattle: a little patience only is necessary, until both ploughmen and cattle become accustomed to the work, when everything will go on smoothly. I used only two cattle myself in such ploughs; but if three or even four are deemed advisable, it will make but little difference in the cost.

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* Reckoning the rupee at two shillings sterling.

Nor had I the smallest difficulty in getting the natives to use it for me; on the contrary, because I raised their wages one pice a day, I had the constant services of my established ploughmen; in fact one of them was a mere boy, who, however, performed his work as well as the others.

It may, and often does, happen that the planter is to enter into possession of lands immediately after the rubbee crop (wheat, barley, &c.) is reaped, which is generally in the early part of March; so that if he intends planting in April, he has only one month to prepare them in, which will allow of no manuring. This, however, is of no great moment, as the commencement of the rains is the signal for that operation.

Advantage is very frequently taken (in Goruckpore and Ghazeepore) of the moonlight nights for ploughing, if the hot winds are very severe during the period of planting; and, indeed, I consider it a very excellent plan wherever it can be adopted, as the land is not so much burnt up as it would be were the work to proceed in the day-time.

If the planter can obtain his land from the ryots, immediately after the paddy (rice) crop is harvested, he then has ample time to plough it up thoroughly, manure it, and in every way prepare it for planting in February, March, and April; which crop would be fit for cutting in the following November and December.

Provided ample means are at hand to irrigate the canes when they are planted, and at periods subsequently, I consider the month of April the most favourable in the year for planting. We may reckon on one irrigation at the time of planting, two at after periods, six hoeings, and six thrashings, during the seven or eight months they are growing. Planted in February or March, of course they require a great number of irrigations and hoeings; not to mention the longer exposure to the attacks of white ants and wild animals, and the maintenance of watchmen during that time. In short, the expense and risk of ten, eleven, or twelve months, are reduced to seven and eight months; which is very important.

The months of September, October, and November, have also their advantage; which, however, consist chiefly in their canes being fine tall vigorous plants by the time the hot weather sets in; but they still require the assistance of irrigation to help them over the hot months, and are generally much cut up by white ants and other enemies: hence I prefer the spring months. But a planter is very often obliged to plant when he would much rather not do so. However, I think, with a good irrigating machine, and under other favourable circumstances, he need not allow himself to be so coerced to any great degree; as he certainly could have no great difficulty in setting to work at once, one or even two dozen such ploughs as have been described. This number would prepare and plant out a large quantity of land during thirty days, or whatever other short period the circumstances of the case might limit him to. The real difficulty would then be, to obtain sufficient cane tops and cane cuttings to plant out the land as fast as it is prepared and trenched. Of native canes there can be no want, as they are in such great abundance on every hand; but as they are not of the variety likely to be selected by the planter, means must be adopted to secure a supply of the superior descriptions, such as the Otaheite, Salangore, and others. If none are to be obtained in the neighbourhood, recourse must be had to "the Society's" garden at Calcutta, from whence a supply can always be obtained. These, planted out judiciously, and carefully attended to, will soon furnish canes wherewith to extend.

This process is comparatively tedious, but it is that which I, in common with many others, have had to follow: the Otaheite cane, however, is now so much more common in India, that perhaps the difficulty may not be so great. It is not a bad plan to plant the best kind of native cane obtainable as a working crop, until the nurseries of Otaheite produce sufficient to extend its cultivation; thus gradually pushing out the native cane, to make way for the Otaheite, until the latter alone occupy the fields.

It is well known that the few upper joints of the cane, comprising what is termed "the cane top," is the best for planting; but as every joint having a perfect eye will grow, the planter is obliged, in the absence of a sufficiently abundant supply of the former, to cut the cane up in pieces (termed plant cuttings) and plant his fields with them. This leads me to notice the peculiar method practised by the natives, and often adopted by European planters, of burying these pieces of cane or plant cuttings in a pit, until they sprout, when they are carefully removed and planted out in the fields. In placing them in the pit, much care is bestowed that they be in regular layers, having wet straw, and a little mould between each layer; and in taking them out, they must be handled very delicately, otherwise the young shoots (which are quite white and tender) are liable to be broken off and destroyed. I tried the experiment several times, and found that when planted out into hot moist ground, the plants throve well; but in cold damp ground, they were completely checked, so that few succeeded: and, again, in hot dry land (not irrigated), they were burnt, and generally withered away.

Hence, I deduced that, during the cold season, it did not do to plant them in wet land; nor indeed did they succeed well in any land; but in February, when the soil had been moistened by a fine shower, and during the hot season, when the land had been irrigated immediately before planting, I found they answered very well indeed; only requiring (in the hot season) to be planted at a good depth. On the whole, however, I do not think any good can be expected from such a system, except during the hot season, when I certainly perceive considerable advantage in it;

although the expense is rather increased, in consequence of the care with which the plants must be removed and planted out.*

Otaheite canes planted in February, March, April, or May, must be planted in regular lines, six feet apart, and two feet distant from each other along the rows; allowing two tops (or cuttings) to each stool, or one top, (or cutting) if planted within one foot of each other. I rather prefer the latter plan, of planting tops along the trenches, one foot from each other; for we then have not two plants struggling for existence in so confined a space, as when we plant two tops side by side. The canes being planted, and supplied when necessary, the planter must irrigate, mould, and clean his fields, until the rains set in, when his canes will begin to grow with astonishing rapidity; rendering necessary his utmost attention in cleaning, banking, and trashing.

Banking must be given, otherwise the canes, being top heavy, will fall over and expose their roots; but by being well banked up, their hold in the ground is more firm, and their support better assured. Trashing (in rich land), is very much required during the wet season, and must be often had recourse to; taking care to deprive the plants of every dry and fading leaf, but not of any green and useful leaf. This constant trashing must be continued until the end of the rains; but after that period at longer intervals, as circumstances may dictate.

If required for manufacture in November and December, as is probable, the canes will require to be trashed once in October; and again one week before they are cut: perhaps circumstances might justify even two trashings in October; as, for instance, when the canes are growing very dense together, and appear very aqueous: but though, under these circumstances, it becomes necessary to trash as much as possible, still we must bear in mind the necessity for leaving untouched every working leaf.

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* Large quantities of cane can be cut up, and thus kept in pits in the fields, until those fields are ploughed up and ready to be replanted; whereas they would otherwise become dried up.

By observing these rules with caution, the planter will have fine canes to grind in November and December, being at that time only from eight to ten months old; and they will give him a rich and abundant juice, which will make him excellent sugar.

I have particularly remarked (at pages 116 and 117) on the advantages to be gained by the possession and employment of an auxiliary locomotive engine on estates in the West Indies and the Straits Settlements; but certainly to no part of the world can an engine of this description be more applicable than to Bengal. I would, however, prefer two, or even three, separate locomotives, of about four horse power each, to one of eight or ten horse power.

These small handy engines could convey themselves to the different wells, ponds, or rivers on an estate, and pump water for irrigation during the whole of the hot season; and at the same time they could be employed during the clear nights in ploughing lands, and might perform besides a variety of other work. The Bengal planter, will, I hope, soon perceive the necessity of establishing estates methodically and on some regular plan, instead of taking up lands from the natives in small detached patches, so as to have his cultivation extending over some miles. I know the difficulty of getting land in large, unbroken tracts: but this difficulty can be got over; and a run of five hundred beegahs (which will form a fine estate), can by little patience and liberality, be obtained on lease, from many of the Zemindars, as I well know. A compact estate of this kind will admit of many systematic plans being laid down, which cannot be where cane pieces are so widely and capriciously scattered, as is common in India at present. I have elsewhere mentioned elephants as being extremely serviceable on estates in the Straits Settlements, and it may be supposed that they must be equally so in Bengal;

which, to a certain degree, is in reality the case: but in parts removed from heavy jungle tracts, their maintenance would be expensive, and in the rainy season their large feet and great weight would cut up the land in a manner very undesirable; while at the same time they cannot endure such continued work in the hot season as bullocks can. Besides all which, their first cost would each equal the price of eight good young cattle, such as would perform work equal to, if not more than, one elephant could.

Dr. Keith Scott has informed me that his elephants perform excellent work on the estate he settled at Gowhattie in Assam; ploughing lands, drawing carts, and performing numerous other kinds of labour. He described them as the most useful animals possible on an estate, and at the same time very cheap; all which, as being applicable to Assam, I am convinced must be strictly correct: but betwixt Assam and Bengal a very great difference exists, which induces me to prefer bullocks for field labour in Bengal. It must be particularly observed by the planter that I speak of bullock work, obtainable from animals well fed, comfortably housed and carefully attended to; not that resulting from wretched, half-starved, and neglected beasts.

In this respect the planter may with profit to himself mark the great change which has of late years characterised the feeding, treatment and working of horse-kind in England. It is very uncommon now to see a meagre, ill-fed horse, in and about London, or indeed in the country. This struck me so forcibly on my return to England from India, that I remarked it to a friend, who immediately replied, "Aye, the fellows have found out that the better they feed their horses, the more work they can get out of them: it pays them compound interest, whilst by half starving them they lose money. Yes; my dear sir, it is self-interest, not humanity that makes our people feed their horses so well as to call forth your remark."

Perhaps the Bengal planter may consider this a "hicmut" worth trying: I certainly hope he may, for at present the miserable cattle are sadly neglected. I remember a neighbour of mine once losing 400 out of 1,200 cattle belonging to him; and was not a little amused at hearing the loss ascribed to a "murrain:" especially when I only lost two cattle out of 200, and these two had been for a long time ailing. I visited my unfortunate neighbour, and one or two others who had been also considerable losers by this fancied murrain; when the cause of such mortality was quite apparent to me. The simple fact was, that the hot season had been extremely severe, so as to scorch up the whole country and leave no vestige of grass; in consequence of which, these large herds had been reduced to the leaves and young plants in the forest, together with the few cane leaves resulting from the sugar canes cut during the season for sugar manufacture. This most scanty subsistence was rendered more severe in its effects by the hard work imposed on the miserable animals at the same time. I saw eighteen and twenty bullocks labouring in each sugar mill (of which there were two at work on the property) and by dint of constant whipping they were made to grind their allotted quantity of canes: spells of these skeleton cattle thus relieved each other from five o'clock in the morning until late at night, when the mills stopped work. Had they been in good condition, the mere working regular spells in the mills, would have been but ordinary and fair work; but the whole secret rested on a point of false economy, in the provisioning, during the hot months: this I must explain.

The natives of many districts in India, on the approach of the hot season, send off their village herds of cattle to the "terai" and other feeding grounds, in order to keep them alive during the three months of hot weather; but the European planter, not wishing to do this, is compelled (if he wishes to save his cattle) to purchase from the villagers around, as much rice straw and chaff as will serve to provision his herd, during three or four months. Now, to feed 1,200 cattle in this manner is no trifling matter, although it is quite necessary; and it seems that my neighbour neglected, or was unable, to lay in a sufficient stock, so that many died, from pure starvation and hard work, before the rains commenced; but no sooner did the watery green grass spring up, than the hungry animals greedily devoured large quantities of it, which had the effect of purging them most grievously. This, in their emaciated condition, they could not withstand, so that they died off, as if they had indeed been seized with a murrain. This is the plain and simple solution of the question; which was abundantly corroborated, by the fact of my losing no cattle (save the two which had been long sick) during this period; for mine were amply provided for during the hot season, and were only allowed to graze a little every day for some time after the rains set in; having still dry food to eat and plenty of black salt to lick. From the foregoing it must be evident that cattle in Bengal must be liberally provisioned during the dry weather; and that working cattle must at all times be kept in the best possible condition, otherwise they cannot be expected to perform anything like a satisfactory day's work. I cannot but mention a brutal practice of the native ploughmen, which is, that of twisting the tails of the cattle; and I trust no European will permit such cruelty to be practised on his cattle. Almost every working bullock met with in India has its tail twisted, either into all manner of forms or entirely off: some have full tails, but dislocated in every joint; others have only half a tail; and others again are altogether without one. "Jereewanah kuro" the first man who so tortures the cattle of an estate, and the practice will be abandoned: as I found.

Having made these rather lengthy, though highly necessary, remarks on the treatment and working of cattle, I will conclude my observations on Bengal plantership in particular, by directing attention to two subjects, as yet unnoticed in reference to India.

The first of these is the use of cane-trash as fuel, instead of applying it as manure; and the second the propriety of replanting cane fields every year, or at least every other year. In regard to the use of cane-trash as fuel, ample reasons have already been given, why it should be returned to the soil instead of being burnt; but the mode of application which I would strongly recommend, differs from that which I have advised for the West Indies, and the Straits Settlements, in consequence of the abundance of white ants, in the soil of Bengal (the upper districts especially.) The plan then is to collect the green trash, long tops, and dry leaves in reservoirs (dug in the ground) near the different wells, ponds, or rivers of the estate, until it has become decomposed; when it can be applied to the fields, as will be more particularly treated of in a succeeding chapter. As fuel, wood or coal must be used, and can without much difficulty be procured.

As respects replanting every year or second year, I must say that I have never seen in India really good rattoons. First rattoons may be allowed; but it is an absolute loss of time, labour, and money to attempt second or third rattoons, if they be of the quality I have seen. I also found, that white ants swarmed in the old roots (of the rattoons) and did immense mischief to the growing canes; whereas when planted yearly, or even every second year, the good stirring up the land received went far to break up their abodes, by disturbing and destroying them. Constant ploughings, which include the preparation of land and the subsequent cleanings, mouldings, bankings, &c. have an excellent effect on these terrible enemies to the cane; and they have been known to evacuate, in a great measure, land that had been continually disturbed by ploughings.

The cost of replanting land in India is so extremely small, and the increased return so much greater, that I should think no planter could hesitate a moment in deciding in its favour; especially as his great enemy, the white ant, is so much distressed, and the land so greatly improved thereby.

In replanting, the old roots should all be burnt, and the cane-top plants be planted between the rows of the former crop, so that they do not occupy the same place as the old roots did. When it is determined to allow the rattoons to continue another crop, it will be advisable to cut down the banks (around the roots) and roots, so as to make the field quite level. This last can best be performed with sharp hoes, and when cleverly done, does no injury whatever to the "stools." Irrigation must also be resorted to (as in the case of "plant canes") throughout the hot season; and probably they may also require a liberal watering after the banks and roots are cut down, as it will have the effect of making them spring up again vigorously. This may be calculated on, if the former canes are cut in November or December, as the land is at that time generally pretty dry; but if a good shower falls in those months, of course the necessity of irrigation is removed.

Many of the suggestions that I have made in the foregoing pages on East Indian sugar culture will be found not to apply in those districts more fortunately situated in regard to seasons than those I have had in view; consequently the planters (if their be any) resident in more favoured localities, must make allowance for those differences which he detects.

I have been somewhat diffuse in explaining the systems of cultivation pursued in the West Indies, the Straits Settlements, and Bengal; as also in recommending the particular courses which, in my opinion, are suited to each. I will now add a few remarks on the establishment and arrangement of sugar estates generally, to which I cannot too urgently bespeak attention.

A good fertile soil, congenial climate, and favourable seasons, are of course necessary to the growth, and perfect development of the sugar-cane plant: but in forming an estate, other considerations must be kept in view; such as an easy communication with a shipping port; an abundant supply of good water, wood, or coal, labour, and provisions; fine, level ploughable lands, and a healthy locality. These are the chief objects to be sought for: but there are also many other minor considerations, which an experienced and cautious planter would endeavour to secure. The possession of the most advantageous property, may however be entirely unproductive of successful results, from the ill devised manner in which the lands are laid out, and the want of judgment displayed in conducting the working details of the estate.

To succeed in its fullest sense, an estate should be of moderate extent, compact, and manageable.

In Jamaica, five hundred acres planted out in canes was considered, even in 1831, a large estate; and we certainly may with correctness denominate that amount of cultivation, a fine and sufficiently large estate in any part of the world.

But no extent of cultivation can constitute a fine and valuable estate, strictly speaking, unless it be judiciously planned, and under perfect management: hence I speak of a five hundred acre estate, as it should, and may be organized.

Economy is best effected by the perfect adaptation of the several parts, which ensures the easy working of the whole; thus, a properly organized sugar estate works as smoothly and satisfactorily as a skilfully constructed piece of machinery. We shall soon become accustomed to judge of a planter's ability by the unvarying quantity and quality of the sugar produced by the fields cultivated year after year; and by the funds expended in securing that produce.

We shall learn to scout the idea of lands becoming exhausted, under proper management: such a plea will serve to stamp the character of the responsible manager with professional disgrace. And we shall then find planters attempting no greater amount of cultivation than they have the means of keeping in prime condition.

If an acre of land can yield two or three tons of good marketable sugar, no system of *mis*management should be tolerated, which produces a less annual return. It is much more economical, and far less troublesome, to keep 100 acres of land up to its standard return of 250 tons of sugar, than to obtain the same quantity only from 250 acres: and yet one would not think so, judging merely from the efforts made by many to exhibit an extensive cultivation. What planter but has seen the hurrying from cane piece to cane piece; the morsel of manure dropt here, the apology for a moulding there, and the mockery of a cleaning and trashing in a third place? Those who have been witness to such a system, or rather want of system, well know how it harasses every one and everything on an estate, from the manager himself, down to the wretched cattle.

And after all, what is the result obtained by so much worry and fatigue? Why one-half, or perhaps one-third only, of what such land would have yielded by proper cultivation; or, in other words, what one-half or one-third of that quantity of land would have produced had it been judiciously managed: and that too with one-half the expense, trouble, and anxiety.

The reader then will understand the reason for my denominating five hundred acres of canes, a large estate; and he will not be surprised at my estimating the proper return from such an estate at from 750 to 1,000 tons of dry sugar per annum.

This should be its average crop during a series of years: no falling off should be allowed; its fertility would increase rather than decrease, if the advice given in these pages be attended to, and strictly followed.

I have mentioned five hundred acres of canes as being sufficient to constitute a fine, valuable, and quite manageable estate; one that can well claim a separate manager and manufactory: but if it be intended to form a very large establishment, such as would be the case were a wealthy "company" to undertake sugar operations on an extensive scale, then it would become expedient to divide the land into estates of about five hundred or six hundred acres each.

Thus, in a tract of five thousand acres of land, ten estates of five hundred acres could be formed, each having a separate engine, mill, and clarifiers, as also manager and assistants, and one central manufactory in which the clarified juice (or liquor) would be received, and manufactured into sugar and rum. Each estate would grind its own canes, and clarify the juice, which would then be drawn down into appropriate vessels for conveyance to the central manufactory. All the feculencies from the clarifiers would accompany the clarified liquor in separate vessels, in order to assist in making rum.

The mode of conveyance from the different estates to the central factory, may be by water or by tram road; according to the nature of the locality and the facilities it affords. Under proper arrangements, the clarified juice could not, by any possibility, be affected to its injury, during the very short time occupied in transmitting it to the central factory: indeed, nothing could be easier than to send the raw juice itself (slightly tempered), without risking its turning acid, and thus do away with the clarifiers at the separate estates. I cannot, however, see that any great object would be gained by this latter plan: but I shall have occasion to notice the subject again in its appropriate place.

No system of cultivation and manufacture can be conducted so cheaply and so well, as when it is on a large scale; but each division must work out its part faithfully, and thus contribute to the success of the general result. An establishment of this extensive character can be far better carried out in Malacca* than in any other country that I know of.

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* A work on the three settlements of Singapore, Penang, and Malacca, by the author, will shortly be ready for publication, in which the peculiar advantages offered by these settlements to sugar planters and others, will be carefully pointed out.

CHAPTER IV.

ON MANURES—CHEMICALLY CONSIDERED.

The object which we have in view in manuring our lands, is to keep up a constant fertility, which will enable us to reap from them every year the largest possible crops.

It is but reasonable to suppose that constant cropping would speedily exhaust any soil, unless we return to it, in some shape or other, those substances of which we deprive it; and that this is in reality the fact, every day's experience proves to us. It has often been demonstrated, that if plants grown on any given space of land be ploughed into the soil whilst they are in a green and succulent condition, the fertility of that land is much increased.

This proceeds from the quantity of nutriment those plants have abstracted from the atmosphere during their growth; so that by their being ploughed into the soil whereon they had grown, they afford to it a much greater amount of substances than they received from it, and consequently whatever excess they may furnish, so far enriches the soil.

Some plants are much more remarkable in this respect than others: for instance, lucern ploughed into the soil previous to blossoming, enriches it exceedingly, and in Europe is very much used for that purpose. This is what is termed "green soiling;" and by it, the plant used is made the means of conveying to the soil the carbon and ammonia, which in its growth it extracts from the atmosphere. It also appropriates to its own use the excrementitious matter deposited by other descriptions of plants growing in the soil previously, and deposits its own excrement, which serves as food to others succeeding it. In Europe and all cold climates this excrementitious matter, voided by plants, is much longer passing into putrefaction than in tropical countries; the necessity therefore of adopting a rotation of crops is much greater in the former than in the latter. All plants void excrement, which when acted on by air and moisture, putrifies and becomes converted into "humus," or vegetable matter in a state of decay. This deposit of organic matter is common to all plants, and exercises a very beneficial influence on land, by furnishing it with a substance capable of being converted into humus, which is so desirable in a soil: but plants cannot long be replanted in the same soil without being seriously affected by their own excrement; so much so that at length they altogether fail. Artificial aid, however, induces a more speedy conversion of this matter into humus, than would otherwise take place: this is effected by frequently turning up the soil with the plough or hoe, so as to expose the excrement to the influence of the atmosphere; and by irrigating the land with river water; as the water of rivers and streams contains oxygen in solution, which effects the most rapid and complete putrefaction of the excrementitious matter contained in the soil which it penetrates (Liebig).

I have commenced the subject of manuring, by introducing that which I consider to be the leading features in the system required for the culture of the sugar cane. I would wish to show the simple fact, that the cane can, by the aid of frequent ploughing, altogether manure itself; and where irrigation is added, increased benefit must result.

I premise then, that we take from the soil only the *juice* of the cane, all the other portions being returned to it immediately; and that to compensate for even that portion, we bestow on it all the wood (or coal) ashes, as well as the feculencies resulting from the boiling and distil-houses, and if need be, some portion of our cattle manure also.

Now, before I proceed any further, the account so settled between the planter and his land demands investigation; and I think I shall have little difficulty in showing that the latter has not been prejudiced thereby.

We will first ascertain what we take from the land, when a crop of 5,600 lbs. of sugar, and its usual proportion of rum, is obtained. Pure sugar is composed of carbon, hydrogen, and oxygen; or say carbon, 12 + water 11; but Muscovado sugar contains besides, mineral substances and organic matter, though in very small quantities when well manufactured. The foliage of canes growing on an acre of good land, together with their other green parts, is assuredly from three to four times the superficial extent of the land; and it has been very clearly shown that these parts of the plant have the power of attracting and assimilating the carbon contained in the atmosphere. This atmospheric supply is certainly limited; but that it is sufficient to furnish the quantity comprised in 5,600 lbs. of sugar, and much more, there can be no reasonable doubt. Liebig estimates "that the atmosphere contains 3,000 billion Hessian* lbs. of carbon; a quantity which amounts to more than the weight of all the plants, and of all the strata of mineral and brown coal which exist on the earth. This carbon is, therefore, more than adequate to all the purposes for which it is required." Whilst the cane is growing, it is constantly depositing in the soil, through its roots, the excrementitious matter, which I have already noticed.

Were this allowed to remain undisturbed by the planter, it would accumulate to such a degree that canes would no longer grow on the land; but being exposed by frequent ploughings to the active influence of the air, it becomes transformed by putrefaction into humus, which supplies to the roots of the plants a constant store of nutriment, in the form of carbonic gas and nitrogen. Thus, the very excrement which the plant deposits in the soil, becomes by exposure to the air (and consequent oxidation) a fertile source of genial nourishment to itself, and to the members of its own class succeeding it. The greater portion of this organic matter is unquestionably derived from the atmosphere (as numerous experiments have fully proved); we therefore find that a constant store of manure is being prepared by the plant itself during the whole period of its growth, and that the aid of man is alone required to effect those changes which serve to render that stock of manure available. The ploughings, however, serve to effect other changes than that relating to the conversion of excrementitious matter into humus; as the mineral constituents of the soil are also exposed to the influence of the atmosphere, and undergo a disintegration of a portion of their parts; which thereon becomes, through the medium of water, befitting food for plants.

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* The Hessian lb. exceeds the English lb. by about one-tenth.

Every ploughing, therefore, that land receives may be termed *an atmospheric manuring.* Cobbett says, "A bright ploughshare is the cheapest commodity ever used by a farmer;" and I not only agree with him, but I am also sure that the sugar planter who keeps it bright by constant work, will speedily be convinced that it is the cheapest fertilizer he can apply to his land. We perceive, then, that by frequent ploughings the soil is constantly improving, and that the excrementitious matter voided by the cane is changed from a detrimental into a nutritive substance; so that the cane plant can be cultivated in the same soil for centuries, provided that the same system be continued. In addition to this we must calculate the amount of ashes furnished from the furnace of the mill engine boiler, and that of the evaporators, together with the refuse from boiling and distilling houses.

A good twelve-horse power engine will easily grind sufficient juice to produce 5,600 lbs. of sugar in nine hours; consuming in that time about 1,080 lbs. of common coal, or about 2,500 lbs. of wood: the former of which would yield of ashes, say five per cent. = 54 lbs., the latter about five per cent. = 125 lbs. ashes.

The evaporation and concentration of the juice, say 5,600 gallons, would require the consumption of about 5,600 lbs. of coal, yielding about 280 lbs. of ashes ; but if wood, then about 12,000 lbs., yielding of ashes 600 lbs. According to this calculation (which certainly is a liberal one) we find that there would be available for manuring purposes, if coals alone were used as fuel, 360 lbs. of ashes; or if wood only were employed, 725 lbs., ashes, for every 5,600 lbs. of sugar made; or, in other words, that amount of ashes to each acre of land. The quantity of feculencies and other refuse cannot be reduced to any exact calculation; but every planter knows the large amount which accumulates in the "dunder pond" of an estate having so unwholesome and so improper a receptacle. All these substances, therefore, the land receives in return for the juice expressed from the canes grown on it; and their value may be learned from the "table of manures," which is given in a succeeding page.

But if these, together with the constant atmospheric manuring before mentioned, be found insufficient to compensate for such produce, then the planter can apply the other substances which he may have at command, as cattle, manure, &c. &c. I have hitherto taken into account the compensation which the land demands for the juice of the cane alone; as I hold it to be incumbent on every planter to return to the soil the other portions of the cane plant.

Using the cane-trash as fuel is the most unwise and suicidal practice that I can imagine; and I believe no planter will continue such a system who can possibly obtain a supply of either wood or coal. It has just been estimated that 6,600 lbs. of coal will serve to grind off canes sufficient to produce 5,600 gallons of juice, and to evaporate the same, so as to yield 5,600 lbs. of sugar: which is at the rate of 2,640 lbs. of coal required to each ton of sugar manufactured. Now coal can be landed in the West India colonies at 1*l.* sterling per ton; so that an estate making 250 tons of sugar can obtain sufficient of this fuel to manufacture the same for the small sum of 290*l.* sterling.* Supposing an estate to be situated within anything like a moderate distance from the shipping port, the expense of carting the coal from the wharf would certainly not be equal to the present expense of drying cane-trash, stacking, or housing it, and finally digging and carrying the same when wanted to the "stockhole." Independent of which, there could be no stopping the manufacture for want of fuel, perhaps at the very time expedition is required, when every moment is precious; there could then be no fear of fire catching the trash in the yard, or in the houses, and thus burning down "the works" and perhaps the whole estate, as has frequently happened in Jamaica.

In the Straits Settlements there can be no possible excuse for using cane-trash as fuel; for excellent hardwood is so abundant, and the Malays supply it on the properties so very cheap, that a twelve horse power engine can be kept at work for sixteen hours for about one dollar, (4*s.* 4*d.*)

Indeed, the supply is so vast, and the Malays are so peculiarly fitted both by habit and ability for wood cutters, that were there 1,600 estates instead of sixteen, at work, as at present, they could experience no difficulty in obtaining as much fire wood as they required. Even coals are commonly sold in Penang and Singapore at from seven to nine dollars a ton; and no doubt when the Bornean mines are in full working, they will be still more cheap: although I consider it far more economical for the Straits' planter to use coal, costing even nine dollars a ton, than to rob his cane pieces of the very best manure they can possibly have.

I have already noticed the expense of drying cane-trash in "the Straits," and at times even the impossibility of doing so for weeks together; which renders trash a most uncertain and expensive fuel: the adoption of another description of fuel is therefore imperatively called for in their case, by the most powerful considerations, quite apart from the extreme value of the cane-trash as a manure.

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* I have no means of forming an estimate of the cost of mangrove and other woods for fuel in the West Indies, but in many parts it is very abundant, if not cheap.

There are no old and deeply-rooted prejudices amongst the planters of the Straits Settlements to combat, as is the case with those of the West Indies; and I have pleasure in believing that they will not hesitate to adopt the course so palpably indicated to them by reason.

I have been at pains in the former chapter, to impress on planters, the necessity of returning to the soil the whole of the cane-trash and leaves (in as green and fresh a state as possible); but as a manure, it more properly belongs to the present chapter, and therefore requires a more especial notice here.

It has long been known to a few, that the parts of a plant when dug into the soil around its roots, furnish the very best and most genial nourishment that can be afforded it; but, notwithstanding this, the fact is far from being generally understood.

In the case of sugar-planters, we find that large herds of cattle have been kept up on estates, expensive manures imported from Europe, and various other courses adopted, in order to maintain a degree of fertility in the soil, far less than is desirable and possible; whilst at the same time they were thoughtlessly using as fuel, that choice manure which the cane plant itself supplied in its leaves and trash.

There are few planters who now doubt the perfect efficiency of cane-trash as manure; but there are, no doubt, some who still cling to "the good old system of fly-penning and basket manuring," who still would like to order from England "composts" of every kind: men of "the fine old school," who term all attempts at improvement "dangerous innovations." For the benefit of such men, as well as for the information of all others who may not have had an opportunity of meeting with the interesting facts previously, I will now venture to give an extract, comprising some notes contained in Baron Liebig's very celebrated work on Organic Chemistry. The subject is the vine, and the mode of manuring it: but as the remarks are in every sense applicable to the sugar-cane also, there is sufficient excuse for my introducing so lengthy, but instructive, an extract in this place.

ON THE MODE OF MANURING VINES.*

"The observations contained in the following pages should be extensively known, because they furnish a remarkable proof of the principles which have been stated in the preceding part of the work, both as to the manner in which manure acts, and on the origin of the carbon and nitrogen of plants. They prove that a vineyard may be retained in fertility, without the application of animal matters, when the leaves and branches pruned from the vines are cut into small pieces and used as manure. According to the first of the following statements, both of which merit complete confidence, the perfect fruitfulness of a vineyard has been maintained in this manner for eight years, and according to the second statement for ten years.

"Now, during these long periods, no carbon was conveyed to the soil, for that contained in the pruned branches was the produce of the plant itself, so that the vines were placed exactly in the same condition, as trees in a forest which received no manure. Under ordinary circumstances a manure containing potash must be used, otherwise the fertility of the soil will decrease. This is done in all wine countries, so that alkalies to a very considerable amount must be extracted from the soil. When, however, the method of manuring now to be described is adopted, the quantity of alkalies exported in the wine, does not exceed that which the progressive disintegration of the soil every year renders capable of being absorbed by the plants.

"On the Rhine, one litre† of wine is calculated as the yearly produce of a square metre of land (10.8 square feet English). Now if we suppose that the wine is three-fourths saturated with cream of tartar, a proportion much above the truth, then we remove from every square metre of land, with the wine only, 1.8 gramme of potash. 1000 grammes (1 litre) of champagne yield only 1.54, and the same quantity of Wachenheimer 1.72 of a residue which, after being heated to redness, is found to consist of carbonates. One vine-stock, on an average, grows on every square metre of land, and 1000 parts of the pruned branches contain 56 to 60 parts of carbonate, or 38 to 40 parts of pure potash. Hence it is evident that 45 grammes, or one ounce, of these branches contain as much potash as 1000 grammes (1 litre) of wine. But from ten to twenty times this quantity of branches are yearly taken from the above extent of surface. * * * *"

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* See Liebig's Organic Chemistry, by Dr. Lyon Playfair, page 211.

† About $22\frac{1}{11}$ ounces.

On the manuring of the soil in vineyards.—"In reference to an article in your paper, No. 7, 1838, and No. 29, 1839, I cannot omit the opportunity of again calling the public attention to the fact, that nothing more is necessary for the manure of a vineyard than the branches that are cut from the vines themselves. My vineyard has been manured in this way, for eight years, without receiving any other kind of manure, and yet more beautiful and richly laden vines could scarcely be pointed out. I formerly followed the method usually practised in this district, and was obliged in consequence to purchase manure to a large amount. This is now entirely saved, and my land is in excellent condition. When I see the fatiguing labour used in the manuring of vineyards — horses and men toiling up the mountains with unnecessary materials—I feel inclined to say to all, come to my vineyard and see how a bountiful Creator has provided that vines shall manure themselves, like the trees in a forest, and even better than they. The foliage falls from trees in a forest only when they are withered, and they lie for years before they decay; but the branches are pruned from the vine in the end of July or beginning of August, whilst still fresh and moist. If they are then cut into small pieces and mixed with the earth, they undergo putrefaction so completely, that, as I have learned by experience, at the end of four weeks not the smallest trace of them can be found."

"*Remarks by the Editor.*—We find the following notices of the same fact in Henderson's History of Wines of the Old and New Time:—

"The best manure for vines is the branches pruned from the vines themselves, cut into small pieces, and immediately mixed with the soil."

These branches were used as manure long since in the Bergstrasse. M. Frauenfelder says: "I remember that twenty years ago, a man called Peter Müller had a vineyard here which he manured with the branches pruned from the vines, and continued this practice thirty years. His way of applying them was, to hoe them into the soil after having cut them into small pieces. His vineyard was always in a thriving condition; so much so, indeed, that the peasants here speak of it to this day, wondering that old Müller has so good a vineyard, and yet used no manure."

Lastly, Wilhelm Ruf of Schriesheim writes:—"For the last ten years I have been unable to place dung on my vineyard, because I am poor and can buy none. But I was very unwilling to allow my vines to decay, as they are my only source of support in my old age; and I often walked very anxiously amongst them without knowing what I should do. At last my necessities became greater, which made me more attentive, so that I remarked that the grass was longer in some spots where the branches of the vine fell, than on those on which there were none. So I thought on the matter, and then said to myself, if these branches can make the grass large, strong, and green, they must also be able to make my plants grow better, and become strong and green. I therefore dug my vineyard as deep as if I would put dung into it, and cut the branches into pieces, placing them in the holes and covering them with earth. In a year I had the very great satisfaction to see my barren vineyard become quite beautiful. This plan I continued every year, and now my vines grow splendidly, and remain the whole summer green, even in the greatest heat. All my neighbours wonder very much how my vineyard is so rich, and that I obtain so many grapes from it, and yet they all know that I have put no dung upon it for ten years."

In this extract, we have numerous instances afforded us of the wonderful efficacy of the vine prunings as a manure to the vine itself; and we are informed that no manure was given to compensate for the substances taken from the vines annually in the form of grapes: nothing but the mere prunings were returned to the soil, yet vines so treated were found during ten years to continue in splendid condition, and yield a maximum quantity of rich fruit.

Now this is precisely my opinion as to the results to be expected from manuring sugar-cane fields with the sugar-cane itself, minus the juice extracted from it.

I feel quite convinced that if all the green leaves and green trash be ploughed into the soil whilst yet green and fresh, that the cane would require no further manuring, save that which I have denominated "atmospheric manuring,"—*id est*, ploughing.

It has been estimated by numerous planters and others, that not more than fifty per cent. of the weight of the cane is obtained from it as juice, by the ordinary mills used for crushing, on estates in the West Indies; whereas it has been satisfactorily demonstrated that the plant consists of ninety parts of fluid, and ten parts of woody fibre. This subject will be more minutely entered on as we proceed: but it is necessary to note, that seventy-five per cent. can be, and is at times obtained by the mills, which will be hereafter described; leaving, in the form of green cane-trash or megass, its proper parts of woody fibre, and fifteen per cent. of unexpressed juice. In the case of inefficient pressure, such as shows an amount of juice, not exceeding fifty per cent. of the whole weight of the cane, of course the remaining fifty per cent. is received again by the soil, under the system of manuring with cane-trash. Calculating, therefore, that the quantity of juice expressed amounts to seventy-five per cent. (with good and efficient mills), then the green cane-trash or megass available for manure will be twenty-five per cent. of the whole taken from the land. Now plant-canes generally average from 30 to 35 tons an acre, which would give, if of the former weight, 7½ tons of green-trash; or if of the latter, then 8¾ tons, as manure per acre, independent of the long-tops and the dry leaves: the former being generally used as fodder for the cattle on the estate, and the latter not unfrequently burned, either at the works or on the field. Taking, however, the green-trash alone into the present estimate at 8 tons, and valuing it at the low rate of 10*s.* per ton, we have the sum of 4*l.*; which we must now contrast with the cost of coals, sufficient to grind the canes, and manufacture the 24 tons of juice into sugar. Even allowing that this amounts to 3 tons at 1*l.* = 3*l.*, we find a balance in favour of the cane-trash of 1*l.*; which is only the relative expense of either in regard to fuel.

Canes, then, can be manufactured at the rate of 1*l.* per acre cheaper by using coals than by using cane-trash as fuel; whilst they can always be carted to the property (if at a distance) by the carts that take the produce to the wharf or shipping place, without entailing any additional expense worthy of being noted. But how are we to estimate the value of the cane-trash manure, except by considering that by its use we ensure the production of a large after-crop: a crop so abundant as to equal the preceding, and still continue from year to year the same average? It must be remembered that in returning to the soil 8 tons of cane-trash, we supply the exact materials requisite for the production of a similar crop: there is not a single constituent but what is needed, and will therefore be used; which certainly can be said of no other description of manure.

In the growth of the cane-plant, the atmosphere conduces largely to the supply of nourishment necessary to its full development, not only in respect to its juice alone, but also in regard to the whole plant; thus the constituents employed in the formation of the leaves and stalks (as well as the juice) have not been derived from the soil alone, but have been extracted from the atmosphere to an equal, if not far greater, degree. Hence it occurs, that by returning the whole of the leaves and trash, we compensate the soil for the contents of the juice which we do not return. The practice of feeding cattle on the long-tops (green leaves on the upper portion of the cane) is a most wanton violation of the science of agriculture; which is the more unpardonable as guinea-grass is so easily cultivated, and can be so abundantly procured: at least in the West India Islands, and every part of India that I have been in. Guinea-grass is also a most nutritious fodder; and on estates, fields can always be kept in rich culture by occasional ploughings, and manuring from the cattle-pens: but, like other plants, this grass has never, to my knowledge, been cultivated as it should be in the west.* I have already frequently observed, that the long-tops and green trash should be ploughed into the soil immediately the cane piece is cut, and before the sun has had time to dry up their moisture: in fact, levelling the banks, and thus covering in the long-tops and green trash should begin immediately the first cart-load of the latter arrives in the field from the mill; thus, cutting canes would be going on in the middle of a field, and levelling at the end first cut, making the two operations to be simultaneous. The parts which are green and moist, undergo putrefaction very rapidly, and are thereby converted into humus. This rapidity of putrefaction is as apparent in the case of the cane-trash and leaves, as in that of the vine-prunings quoted; but the process is either quicker or slower according to the nature of the soil, and the moisture presented to it: thus, in a porous soil, where the air can penetrate freely, it is very rapid; whilst in heavy, cohesive land the time occupied is much greater. But the yearly application of vegetable matter (such as cane leaves and trash), together with the effect of frequent ploughings, will in time render the heaviest clay-soils porous: but the addition of sand much expedites this desirable effect.

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* Guinea-grass should be planted in rows at regular distances apart, as mentioned at page 64, and even at distances along the rows, so that the plough and cultivator may work between the roots, eradicating weeds and disintegrating the alkaline constituents of the soil. In this manner, after the field has been manured, Indian corn (maize) may be planted between the rows, and be ploughed into the soil after the "ears" have been plucked; thus making a field supply both corn and grass without becoming impoverished. The grass must always be cut, not fed down.

Planting beans, peas, lucerne, indigo, or other plants between the cane-rows (when canes are first planted), and afterwards ploughing them into the soil, whilst green and succulent, has a powerful effect in fertilizing land, and when performed entirely by agricultural implements may, even in the West Indies (where labour is expensive and scarce), be practised without any great expense. Indigo is a very valuable plant for such a purpose as this, and may be planted by a drill (in regular lines), just at the commencement of the rains, and in two months after, be uprooted, laid along near the roots of the young canes, and moulded over: the only part of these operations necessary to be performed by hand labour, is the uprooting and placing them evenly along the cane rows, so that the plough following may cover them over completely and neatly. I must also remark, that if the indigo plants are cut (to within a few inches of the ground), when they have attained a good height and shew a fair bush, instead of being rooted up, they will again spring forth amazingly quick, and furnish another fine, bushy plant (before the end of the rains), which may then be rooted up and moulded over as the first. This latter plan presents the advantage of two crops being afforded to the soil instead of one, at the expense only of the cutting; which, when the labourers have sharp sickles, is very quickly and neatly performed, and cannot entail any great expense. The indigo plant so applied furnishes a very rich manure for the cane, to which culture it is continually appropriated by the natives of India; although not until the colouring matter, forming the indigo of commerce, has been extracted, and the plant becomes partly decomposed: but in the Straits, the Chinese who cultivate indigo, first extract the colouring matter from the plants, then take them at once, all dripping with moisture from their vats, to their cane patches, where they lay them carefully along the roots of the canes, and then mould over them. I have seen Chinese in this manner produce excellent canes from land so sandy and otherwise unfertile, that no European planter would for a moment think of planting canes in such land. Thus it is (in Province Wellesley) that, wherever a Chinaman cultivates indigo, he is always sure to cultivate a patch of canes also.

Indigo seed of the best description may always be obtained in Calcutta, and generally at a cost of about six rupees (say 12*s.*) a maund of 80 lbs.; 8 lbs. of which (if good fresh seed), will serve to plant out one acre of cane land. It may be well to mention that Indigo must be planted either at the commencement of the rains, or be frequently and plentifully watered, if at other seasons; hence, wherever the means of irrigation are available, this "green-soiling" may be practised all the year round. I cannot but consider it a very cheap and ready means of keeping up the fertility of cane soils; and it is more especially deserving of the planter's consideration, in cases where the cane-trash (from whatever cause it may arise), is used for fuel instead of being returned to the soil. Indigo, to grow luxuriantly, requires a generous soil, consequently will only answer the planter's expectations when so planted: for instance, after the land has been manured; in which case it will spring up vigorously and luxuriantly, furnishing, when cut, an immense accession to the soil, as its numerous leaves so powerfully attract nourishment from the air.

I have myself seen such numerous instances of the remarkable effect of this manure on canes, that I can recommend it to the planter with every confidence.

As I have before said, a great variety of plants may be used in the same manner as the indigo: but it is very essential to remark, that the greatest good can only result from ploughing in the plants whilst quite green and succulent;

and that the best time for so doing is just before they prepare to blossom.

I have known planters who planted beans and peas amongst their canes, with the excellent intention of digging in the plants around the young canes; but an over anxiety to secure the beans and peas resulting, always seemed to make them forget the object in view: thus the plants were always dry before they were dug in, and consequently the land was no way benefitted.

Having now gone over what I consider to be the truest system to be pursued in manuring an estate, I will proceed to give a brief Table of Manures; such as are within the reach of every planter: first premising that in addition to carbonic acid, water, and ammonia, (which are necessary to the existence of all plants), the sugar-cane requires silica and potash (in the form of silicate of potash) phosphates and other substances peculiar to the plant.

The great source of "carbonic acid" is the atmosphere; from which it is extracted by the leaves and green parts of plants, as before mentioned. It is also supplied by humus (vegetable matter in a state of decay) and a vast variety of substances. "Ammonia" is also largely derived from the atmosphere, rain water, and various manures; as will be presently shown. "Silicate of potash" is obtained by irrigation, (as it abounds in the water of rivers and streams,) mineral earths, ashes of various plants, from the excrement of various animals, &c., &c., &c. "Phosphates" are very numerous, being eighteen in number; but they are supplied to the soil, by way of manure, in the form of ground bones finely pounded, (which, mixed with sulphuric acid, form phosphoric acid,) in the ashes of plants and in animal manures.

TABLE OF MANURES.

Ashes from the engine boiler, evaporators, and rum still. These divide into coal ashes, and wood ashes.

Coal ashes, variable; generally silica and alumina, with small quantities of lime; sometimes magnesia, and also peroxide of iron.

Wood ashes, variable; usually potash, lime, soda, magnesia, silica, the oxides of iron and of manganese, chlorine, carbonic acid, sulphuric acid and phosphoric acid; sometimes alumina occurs, and even oxide of copper, but both very rarely.

Cane-trash and leaves, in decay, become humus, and supply an abundant store of carbonic acid and nitrogen to plants growing in the soil, in which they are embedded; their ashes contain silicate of potash, carbonates of lime and potash; phosphates of lime, soda and magnesia; phosphoric acid, oxides of iron, &c., &c.

Feculencies from manufactory; silicate of potash, phosphoric acid, ammonia, and numerous other constituents.

Humus or vegetable matter in a state of decay; carbonic acid, nitrogen, &c.

Cow dung and sheep dung; phosphate of lime, silicates of potash, or lime, common salt, &c. &c.

Cow urine; ammoniacal salts, uric acid, and salts of phosphoric acid.

Horse dung and urine, generally silicates of potash and lime and different phosphates. Ammoniacal salts, uric acid, salts of phosphoric acid, &c.

Human fæces; phosphates of lime and magnesia, nitrogen, &c. &c.

Urine, urea; free lactic acid and lactate of ammonia, &c.; uric acid, mucus of the bladder; sulphate of potash; sulphate of soda; phosphate of soda; phosphate of ammonia; chloride of sodium; muriate of ammonia; phosphates of magnesia and lime; siliceous earth and water. (Berzelius's analysis.)

Bones; phosphates of lime, magnesia, &c.; carbonate of lime, &c. &c.

Guano, extremely variable; urate of ammonia; oxalate of ammonia; oxalate of lime; phosphate of ammonia; phosphate of ammonia and magnesia; sulphates of potash and soda; sal ammoniac; phosphate of lime; clay and sand; water and organic matters. (Analysis by Fourcroy and Vauquelin.)

Lime; common lime or quick lime.

Marl; carbonate of lime, clay and sand.

Clay; alumina and silica, generally tinged with iron. Lime, magnesia, and other metallic oxides are occasionally present in certain natural clays.

Sand; silex or silica, carbonate of lime, &c. &c.

Mud from rivers and ponds; argillaceous earth, carbonate of lime and vegetable matter.

Gypsum; sulphuric acid, lime, and water.

Salt; chloride of sodium, &c.

Salt water; chloride of sodium; sulphate of soda; sulphate of lime; chloride of potassium; and chloride of magnesium.

Charcoal, carbon; is valuable as a manure by reason of the quantities of carbonic acid, and ammonia, which it attracts from the atmosphere, and supplies to the roots of plants.

Chalk, variable; a friable carbonate of lime, sometimes containing also small portions of alumina, oxide of iron and silica. When it is what is termed "soap stone" or "soapy chalk," it contains a predominant proportion of magnesia.

Soot; a pulverent charcoal condensed from smoke; pitcoal soot contains some sulphate and carbonate of ammonia, together with bituminous matter (according to Ure.)

All these substances are within the reach of most sugar planters: but probably guano and salt-water may not be, if far removed inland. However, the others are certainly abundant enough, and can be obtained without any difficulty in the West Indies, Bengal, and the Straits Settlements, as well as in most other parts of the world where sugar canes are cultivated.

Having given this Table of Manures, it is necessary that I should remark on the various substances named in it, in order to point out the constituents of each and their particular value in the culture of the cane, &c. &c.

Coal ashes are extremely variable in appearance and composition, in consequence of the great difference existing between the coal of one part of the country and that of another. The quantity also is very variable; some giving of ashes only 1·7 per cent., whilst very few afford more than five per cent.: still there are some yielding from nine to eleven per cent.; as the Glasgow "splint coal," 9·5. "Cherry coal," ten, and "cannel coal," eleven per cent. of ashes; but best Newcastle "caking coal" gives only 1·50 per cent.

Amongst the different varieties, therefore, I have assumed five per cent. as a fair general average; although it is sure to exceed that proportion, unless very great care be taken to sift the ashes well, so as to separate even the smallest pieces of cinder, that they may be returned to the furnace. Some portions of these minute cinders will, however, no doubt remain, and be carted away for manure with the ashes: hence it would be a great advantage if the ashes and the intermingled small cinders were subject to the action of a crushing roller, previous to being returned to the soil. These small cinders are composed of carbonaceous matter, enveloped in an incombustible matter; therefore requiring a higher degree of temperature to reduce them to ashes.

Wood ashes vary according to the description of wood from whence they are derived; hence "mangrove," and other woods grown in a highly saline soil, afford a large proportion of soda salts, especially the carbonate. In the Straits' Settlements the sugar estates would (and do) use more of these descriptions of wood than of any other; not that there is not an inexhaustible supply of dry land forest-wood, but because the high tides afford such admirable facilities for bringing out the wood cut in swamps. I think I have made a very fair general average, in stating the ashes resulting from such wood at 5 per cent.; and there can be no doubt that the minute pieces of unburnt charcoal, removed with the true ash, will bring it rather above that average. The ashes of wood grown on dry land (not saline swamps) very frequently contain one-half their weight of carbonate of lime.

Woody fibre (lignin), whether that of the forest tree, or of the sugar-cane plant, is composed of carbon, oxygen, and hydrogen, and comprises very nearly the whole of what is termed vegetable matter. When burnt it is almost entirely dissipated, little other being left as ashes, save the mineral constituents derived from the soil. Thus in burning vegetable matter (in contact with air) we lose from 90 to 97 per cent. of the elements of which they were composed; which serves to expose to us the mischievous practice of burning off the dry leaves and cane-trash remaining on a cane-piece after it is cut. The same leaves and trash being buried in the soil, instead of being burnt, would furnish for succeeding crops the addition of 90 to 97 per cent. which they otherwise lose; as the very small per centage of ashes can form but an extremely inadequate substitute for the rich constituents dissipated and altogether lost by burning. Hence I consider that burning off the trash of a cane-field is an ill-judged and ruinous practice, which the planter should only adopt in very extreme cases; such as a swarming of insect matter, destructive to the cane-crop, (as the "borer," and others). These insects often so abound in a cane-piece, that burning off the trash has been found the only effectual means of destroying them; as the larvæ may be buried in the soil, together with the cane-trash, without receiving the least injury, so that, at their appointed time, they burst forth into active life, and commit fearful havoc amongst the growing canes. Some estates will require a burning off of this kind generally once in five or seven years, but I never knew one that demanded it oftener.

I have calculated that on each acre (producing 5,600 lbs. of sugar) 725 lbs. (nearly 6½ cwt.) of wood ashes could be applied as manure for every crop; which ashes are supposed to be the residue of wood consumed in the furnaces of the manufactory. Of these ashes, only a portion is soluble, until it has passed through certain transformations: the soluble part consists of the alkaline sulphates, carbonates, and chlorides; and the insoluble portion chiefly of carbonate of lime, and probably magnesia, phosphate of lime, phosphate of iron, &c. &c. Therefore, to render immediately available the whole of the constituents of the ashes, it would be necessary to separate the soluble from the insoluble parts: say by pouring on them some hot water from the steam engine, and stirring the mixture well for some time; then, when it has subsided, drawing off the alkaline ley, which would contain however but a portion of the solubles comprised in the ashes; treating the latter with sulphuric acid to liberate the phosphoric, in order to dissolve the phosphates, and thereby allowing the free phosphoric acid liberty to combine with the alkaline earths contained in the soil.* Another method is to mix ashes (in heaps) with small portions of decaying vegetable matter, keeping up a sufficient moisture and warmth, whereby a fermentation is induced, and the ashes become converted into mould; or, in other words, the putrefactive process is rapidly accelerated, and the ashes thereby speedily transformed into soluble substances. If applied in their crude state, the insoluble parts remain unavailable as nourishment to plants, until, in course of time, the changes effected in the soil bring about an alteration of their characters. Ashes likewise absorb moisture from the atmosphere, and retain it; in addition to which their mechanical influence is valuable, as opening heavy soils and conducing to their porosity.

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* On the same principle as that of Law's Patent Manure. May, 1842.

Cane-trash and leaves.—I have already said so much on this subject that there remains little more to be added. In all countries not infested by that formidable enemy, the "white-ant," I strongly recommend the return to the soil of every portion of the cane the instant it can be effected: the cane leaves removed in trashing the moment they are taken off (as recommended at page 72); and the long-tops and green-trash immediately the latter can be brought from the mill to the field—which should be by the same carts that take the canes from the field to the mill. I would have no dung heaps, nor "compost reservoirs," but return every portion to the soil immediately, and allow it there to undergo the fermentative and putrefactive processes.

But, in many parts of India, cane-trash could not be so applied to the soil, except just at the commencement, and during the continuance of the rains; which is a season when manufacturing is never carried on. Were cane trash to be returned to the soil at other periods, the land would immediately become a perfect hot-bed for white-ants, and quite ruined for sugar-cane culture: the system then is, to have cane-trash reservoirs dug, near the different wells or ponds on the estate, into which the cane-trash, ashes, and various vegetable collections should be deposited. In this manner, as the irrigation of the fields proceeds, and at all times, water could be conducted into these receptacles, so as to keep up rather an excess of moisture, in order to deter the white-ants from making them their abodes; which they could not do when too much moisture was present. At the same time, the fermentative process would go on but slowly (comparatively speaking), from water being always in excess: thus the accumulated vegetable matter would be found in a very desirable condition when required to be applied to the land in June, when the rains commence. Being then laid on the land, and immediately ploughed in, the fermentative process would speedily be completed in the soil.

A great deal depends on the manner in which this (as well as all other descriptions of manure) is applied to the soil, and a very great deal of after trouble and disappointment may be saved by exercising a little judgment in the first instance.

If lands are being prepared for canes, (and not yet planted), the best plan will be to put in as many ploughs as can be spared, on the occurrence of the first shower of rain (in India), and plough the land into trenches, as close to each other as conveniently can be done. The manure is then placed in these trenches, and covered over, by the land being hainghered. When all the fields are thus manured, they may remain in that condition for a short time; after which they should be well stirred about, with either the common harrow or the cultivator,* which will thoroughly mix up the manure with the soil.

If this manure, however, has to be given to young canes, the same period of the year must be chosen: but the mode of application differs, inasmuch as it must be laid along the cane rows near the roots, and then moulded over; immediately after which other portions may be placed in trenches, ploughed between the same cane-rows, and covered over by the small cultivator or harrow being run over the ground.

In this manner the whole of the vegetable matter would become available (when converted into humus) for the supply of nourishment to the plants, none being destroyed by the white-ant; which would be unable to molest it during the wet season if the soil were well worked, and, by the time that was over, there could no longer be any apprehension, as the fermentative process would have removed it from that liability.

The wet season, however, forms no safeguard, when the soil is not worked up during its continuance; for these pests form water-tight cells in the ground (about the size of an orange) in a very short space of time, from whence they issue forth on their destructive excursions. I have seen, in a square yard of ground, a dozen such cells, each having a nest contained in it; and they always appeared to me to be mere temporary abodes, constructed on a principle quite distinct from that of their large nests, and are very often found empty, its former occupants having doubtless returned to the general nest.

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* Ransome's Indian Cultivator is an excellent implement for this purpose.

The fermentative process converts cane-trash and all other vegetable matter into *humus*, the existence of which in a soil is so essential to fertility; the further notice of cane-trash as a manure* may therefore be referred to the remarks under that head.

Feculencies from Manufactory.—These comprise the fecula separated from the cane-juice during the process of clarification and evaporation, and the refuse resulting from the still-house in the form of "dunder;" which is the wash or liquor that has undergone the operation of distillation, and thereby been deprived of its alcohol. The fecula passes from the boiling-house into the distil-house, along with the washing of the clarifiers, &c. &c., and is received into "receivers," in order to conduce to the manufacture of rum: thus, after it has parted with the portion retained for that purpose, it is usually thrown into the "dunder pond."

This fecula varies much in character, but is generally composed of mucilaginous, gummy, and albuminous matter, in combination with portions of woody fibre and other substances.

According to the analysis of Avequin, it consists of waxy matter, green matter, albumen, woody fibre, biphosphate of lime, silica, and water. Other analyses show different substances, or at least substances which are made to bear different names.

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* As cane-juice exists in the cane in the proportion of ninety parts to ten of woody fibre, and as we only manage to obtain by the best mills (at present) seventy-five of those parts, we consequently leave in the cane-trash fifteen parts, which certainly are the most saccharine portions of the juice. Hence, in addition to mere woody fibre, we return to the soil in the trash, the constituents contained in that quantity of juice.

The "dunder" (from redundar,* to return) is the fermented wash after distillation, which is always returned to the distil-house to contribute to the "setting up" of other wash; but it accumulates so fast that sometimes a large quantity is allowed to run off into the dunder pond. This pond is generally situated near the distil-house (on Jamaica estates), and in it all the waste dunder and other refuse from the distil-house is allowed to accumulate; together forming an exceedingly noxious combination, from which the most loathsome and unwholesome emanations constantly arise.

But, instead of so noisome and pestilential a receptacle being situated just under the very noses of every living creature engaged about "the works," if the planter were to adopt the simple course of carting away (every day) all the dunder and refuse to his dung or manure reservoir, he would not only prevent the existence of so serious a nuisance about "the works," but would also economize much of that which, under the dunder-pond system, is now lost. Let any planter take notice of the quantity resulting from the distil-house a day, and he will find that the mere cartage of this to the reservoir is quite a fractional expense, which cannot be named in comparison with the salubrity and economy effected. That which is usually termed the "lees" (what remains in the still after the distillation of rum from low-wines, or if retorts are used, that left in them) should also be removed to the reservoir, and not thrown away, as is usual.

It is well known that the lees from low-wine is very acrid and corrosive, but few consider that this peculiarity is due to the substances which it contains, and which are unquestionably beneficial as manure, when properly applied. The more acrid and corrosive the lees may be, the more surely does it abound in those substances which have been derived from the cane plant itself; and which therefore ought to be returned to the soil. Mixed with the many matters collected in the manure reservoirs, these constituents enter into combinations according to their nature, and tend to augment the general store in course of accumulation.

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* A Spanish word, literally signifying to redound, to contribute.

"Humus," or vegetable matter in a state of decay, is understood to mean woody fibre in a state of decay. Liebig uses the word "eremacausis," a compound word, signifying slow combustion. He says:—"In organic nature, besides the processes of decomposition named fermentation and putrefaction, another and not less striking class of changes occur, which bodies suffer from the influence of the air. This is the act of gradual combination of the combustible elements of a body with the oxygen of the air; a slow combustion or oxidation, to which we shall apply the term of "eremacausis." The conversion of wood into humus and numerous other processes, are of this nature."

We have here three processes presented to us, viz., fermentation, putrefaction, and eremacausis, which he thus explains:—"Fermentation may be considered as the process of combustion or oxidation taking place in a compound, between the elements of the *same* matter, at a very slightly elevated temperature; putrefaction as a process of oxidation in which the oxygen of *all* the substances present comes into play." * * * * * *

"In putrefaction, the conditions are evidently present, under which the affinity of carbon for oxygen comes into play; neither expansion, cohesion, nor the gaseous state opposes it, whilst in eremacausis all these restraints have to be overcome. The evolution of carbonic acid during the decay or eremacausis of animal or vegetable bodies which are rich in hydrogen, must accordingly be ascribed to a transposition of the elements, or disturbance in their attractions, similar to that which gives rise to the formation of carbonic acid in the processes of fermentation and putrefaction. The eremacausis of such substances is, therefore, a decomposition analogous to the putrefaction of azotised bodies. For in these there are two affinities at play; the affinity of nitrogen for hydrogen, and that of carbon for oxygen, which facilitate the disunion of the elements. Now there are two affinities also in action in those bodies which decay with the evolution of carbonic acid. One of these affinities is the attraction of the oxygen of the air for the hydrogen of the substance, which corresponds to the attraction of nitrogen for the same element; and the other is the affinity of the carbon of the substance for its oxygen, which is constant under all circumstances. When wood putrefies in marshes, carbon and oxygen are separated from its elements in the form of carbonic acid, and hydrogen in the form of carburetted hydrogen. But when wood decays or putrefies in the air, its hydrogen does not combine with carbon, but with oxygen, for which it has a much greater affinity at common temperatures. Now, it is evident, from the complete similarity of these processes, that decaying and putrefying bodies can mutually replace one another in their reciprocal actions. All putrefying bodies pass into the state of decay when exposed freely to the air, and all decaying matters into that of putrefaction when air is excluded. All bodies, likewise, in a state of decay, are capable of inducing putrefaction in other bodies, in the same manner as putrefying bodies themselves."

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"In a soil to which the air has no access, or at most but very little, the remains of animals and vegetables do not decay, for they can only do so when freely supplied with oxygen; but they undergo putrefaction, for which air is present in sufficient quantity. Putrefaction is known to be a most powerful deoxidising process, the influence of which extends to all surrounding bodies, even to the roots and the plants themselves. All substances from which oxygen can be extracted yield it to putrefying bodies. * * * * *

"The frequent renewal of air by ploughing and the preparation of the soil, especially its contact with alkaline metallic oxides, the ashes of brown coal, burnt lime or limestone, change the putrefaction of its organic constituents into a pure process of oxidation; and from the moment at which all the organic matter existing in a soil enters into a state of oxidation or decay, its fertility is increased. The oxygen is no longer employed for the conversion of the brown soluble matter into the insoluble coal of humus, but serves for the formation of carbonic acid. * * * * *

"Humus supplies young plants with nourishment by the roots, until their leaves are matured sufficiently to act as exterior organs of nutrition. * * * * * *

"The atmosphere and the soil offer the same kind of nourishment to the leaves and roots. The former contains a comparatively inexhaustible supply of carbonic acid and ammonia; the latter, by means of its humus, generates constantly fresh carbonic acid, whilst, during the winter, rain and snow introduce into the soil a quantity of ammonia sufficient for the development of the leaves and blossoms. The complete, or, it may be said, the absolute insolubility in cold water of vegetable matter in progress of decay (humus), appears on closer consideration to be a most wise arrangement of nature. For if humus possessed even a smaller degree of solubility than that ascribed to the substance called humid acid, it must be dissolved by rain-water. Thus a heavy and continued rain would impoverish a soil. But it is soluble only when combined with oxygen; it can be taken up by water, therefore, only as carbonic acid. When kept in a dry place, humus may be preserved for centuries, but when moistened with water, it converts the surrounding oxygen into carbonic acid. As soon as the action of the air ceases—that is, as soon as it is deprived of its oxygen—the humus suffers no further change. Its decay proceeds only when plants grow in the soil containing it; for they absorb by their roots the carbonic acid as it is formed. The soil receives again from living plants the carbonaceous matter it thus loses, so that the proportion of humus in it does not decrease. * * * * * *

"The decay of woody fibre (the principal constituent of all plants) is accompanied by a phenomenon of a peculiar kind. This substance, in contact with air or oxygen gas, converts the latter into an equal volume of carbonic acid, and its decay ceases upon the disappearance of the oxygen. If the carbonic acid is removed, and oxygen replaced, its decay recommences; that is, it again converts oxygen into carbonic acid. Woody fibre consists of carbon and the elements of water, and, if we judge only from the products formed during its decomposition, and from those formed by pure charcoal burned at a high temperature, we might conclude that the causes were the same in both: the decay of woody fibre proceeds, therefore, as if no hydrogen or oxygen entered into its composition. A very long time is required for the completion of this process of combustion (eremacausis), and the presence of water is necessary for its maintenance: alkalies promote it, but acids retard it. * * * * *

"The property of woody fibre to convert surrounding oxygen into carbonic acid diminishes in proportion as its decay advances, and at last a certain quantity of a brown coaly looking substance remains, in which this property is entirely wanting. This substance is called mould; it is the product of the complete decay of woody fibre. Mould constitutes the principal part of all the strata of brown coal and peat. Humus acts in the same manner in a soil permeable to air, as in the air itself; it is a continued source of carbonic acid, which it emits very slowly. An atmosphere of carbonic acid, formed at the expense of the oxygen of the air, surrounds every particle of decaying humus. The cultivation of land, by tilling and loosening the soil, causes a free and unobstructed access of air. An atmosphere of carbonic acid is, therefore, contained in every fertile soil, and is the first and most important food for the young plants which grow in it. * * * * *

"Each new radical fibril which a plant acquires may be regarded as constituting at the same time a mouth, a lung, and a stomach. The roots perform the functions of the leaves from the first moment of their formation; they extract from the soil their proper nutriment, namely, the carbonic acid generated by the humus. By loosening the soil which surrounds young plants, we favour the access of air, and the formation of carbonic acid; and, on the other hand, the quantity of their food is diminished by every difficulty which opposes the renewal of air. A plant itself effects this change of air at a certain period of its growth. The carbonic acid, which protects the undecayed humus from further change, is absorbed and taken away by the fine fibres of the roots, and by the roots themselves; this is replaced by atmospheric air, by which process the decay is renewed, and a fresh portion of carbonic acid formed. A plant at this period receives its food both by the roots and by the organs above ground, and advances rapidly towards maturity. When a plant is quite matured, and when the organs by which it obtains food from the atmosphere are formed, the carbonic acid of the soil is no further required."

These very simple explanations of the origin, formation, natural properties, and peculiar actions of humus, serve to render each of those subjects perfectly clear and intelligible to the planter; which fact forms my excuse for making use of such numerous and varied extracts as the above constitute. The preceding extracts show in the plainest manner that humus in contact with air converts the oxygen contained in the latter into an equal volume of carbonic acid, which it supplies to the roots of plants as nourishment: but humus possesses another power, equally important, which I have not yet particularly remarked upon; this is, the power of absorbing and supplying to plants the nitrogen of the atmosphere. Liebig says,—"Decayed wood (humus) approaches very nearly to charcoal in this power; decayed oak wood absorbs 72 times its volume, after having been completely dried under an air-pump. We have here an easy and satisfactory means of explaining still further the properties of humus, or wood in a decaying state. It is not only a slow and constant source of carbonic acid, but it is also a means by which the necessary nitrogen is conveyed to plants."

Now, without nitrogen, plants could never attain maturity:

it is one of the grand essentials to vegetable life, and is contained in the form of ammonia in the atmosphere, and a vast number of substances; as will be more particularly detailed as we proceed. We find, then, that humus supplies to plants two of the great essentials to life and maturity; and from this we can judge of the beneficial influence of all substances as manure which are capable of being converted into humus. When cane-trash and cane leaves are returned to the soil, they speedily become transformed into humus (but this is effected much more rapidly when ploughed into the soil in a green and moist condition); so, indeed, do all descriptions of vegetable matter; which, therefore, shows us that such manure should be carefully collected and applied, as occasion demands, in order to afford our canes an abundant supply of such indispensable nutriment.

Wherever the supply of carbonic acid is abundant, that of nitrogen should also be in proportion, otherwise the plant will not be able to assimilate the carbon with sufficient energy; whereas, when an adequate supply is available, the assimilating power is greatly increased, and the carbon is therefore converted to the uses of the plant in abundance. But although nitrogen is indispensable to all plants, and particularly desirable in large quantities to many, yet in regard to the growth of the cane, and the formation of a highly saccharine juice, this is not the case.

A sufficiency is required to stimulate the cane plant to a due energy in assimilating the carbon contained in the carbonic acid supplied to it by the atmosphere and the soil, so as to ensure a fine, vigorous, well-developed plant: but any in excess of this has an injurious tendency, as it conduces to the formation of gluten or mucilage in the plant instead of sugar. Hence, any manure containing much ammonia is unfit for sugar-cane cultivation. Molasses it will produce in abundance, but at the expense of the saccharine crystallizable principle.

On the other hand, if the quantity of nitrogen presented to the plant be sufficient only to induce a desirable activity in the organs of assimilation, the carbon assimilated, finding no nitrogen with which to combine, (and thus form new substances, such as gluten, albumen, mucilage, wood, &c.) will be deposited in the cells in the form of sugar. It therefore follows, that in manuring land for cane, those substances only should be used which tend to supply a befitting proportion of the elements requisite to the formation of a well-developed plant, and the progressive deposit of sugar in its cells.

I am entirely convinced that humus, when in proper quantities (as is the case when the whole of the cane-trash and leaves is returned to the soil), will be found to attract from the atmosphere, and supply to the cane-plant, as much nitrogen as it requires for its most perfect development, and the consequent deposit of a maximum quantity of sugar in its cells.

Cow, sheep, horse dung, and urine.—If the planter could obtain the former of these excrements free from the strong ammoniacal impregnation they usually receive from the urine of the same animals, there could be no doubt as to their beneficial tendency as manures for the sugar-cane; but mixed, as they generally are, with the urine, they are exceedingly objectionable. In the dung of cows and sheep we afford the land silicate of potash and some salts of phosphoric acid, whilst that of horses furnishes phosphate of magnesia and silicate of potash,* which are all desirable substances in cane culture; but the admixture of urine, by supplying them with ammonia, altogether alters their character and renders their application to cane-fields highly injurious, in consequence of the formation of gluten, albumen, mucilage, &c., in the cane as before noticed.

In the West India Islands, this is the description of manure universally used in the cultivation of the cane; and because excellent crops have been obtained from lands so treated, it has always been maintained as the very type of sugar-cane manure. The excessive quantity of molasses resulting from canes so manured was never attributed to the correct cause, until the celebrated Liebig opened our eyes, and demonstrated that which admits of no gainsaying. Many planters, no doubt, can furnish numerous instances of very rich and pure cane-juice being yielded by plant canes which had been generously treated with cattle-pen manure, and they may be apt to adduce such as proof of the incorrectness of the rules laid down by Liebig; but we should consider that ammonia is extremely volatile, and will readily escape into the atmosphere as carbonate of ammonia, unless prevented by the application of substances (such as gypsum, clay, burnt clay, &c.) which have the property of absorbing and fixing it; and likewise remember the exposed state of the manure collected in cattle-pens on West India estates, during the whole period of its accumulation: sometimes twelve to twenty-four months. If these circumstances are duly considered, it will be quite evident that by far the major part of the ammonia originally contained in the manure had evaporated, and consequently was not liable to effect that amount of injury which fresh manure of this kind undoubtedly would.

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* The dung of these cattle contains nitrogen: but in very minute quantities.

In my own experience, I have frequently known manure to remain accumulating in cattle-pens for upwards of two years, until the whole had become a black mass of a pasty kind of substance, from which only a faint smell of ammonia emanated; clearly showing that a very small proportion of that volatile alkali then remained in it, and that even that portion was fast escaping.

This ammoniacal effluvia, however, was only perceptible on the manure being dug into, for the purpose of being carted off to the fields; during which operation, and its subsequent exposure in heaps, previous to being "dropt" along the rows, it undoubtedly lost three-fourths—if not more—of what remained: so that, by the time it was placed in a position to act on the cane-plants as a manure, the ammonia was almost entirely dissipated. Now, under such circumstances, ammonia was not present in sufficient quantity to work any great evil to the crop which ensued; it was therefore of good quality, and did not produce an excess of molasses.

In cases of "fly-penning," so common in Jamaica, it is usual to allow 1,500 or 2,000 head of cattle to the acre;* thus that extent of land receives the droppings (liquid and solid) of 2,000 cattle and mules during one night of say thirteen or fourteen hours, which certainly cannot amount to less than 6,000 lbs. of urine, and 6,000 lbs. of dung.

This quantity of urine must be very injurious to the quality of the juice resulting from the canes planted on land so treated; but especially so when the soil is of a ferruginous clay, as the metallic oxides absorb and prevent the escape of the ammonia contained in the urine, by forming with it solid compounds.

In certain other soils, the effect is not so injurious; as the constituents of the soil, not being of a character to fix the ammonia, it escapes into the atmosphere, and thus relieves the land.

This is particularly the case when the land remains long unploughed or undug after it has been fly-penned, as the volatile alkali has time to escape; this is also facilitated by the operation of ploughing, as the soil that has been saturated with the urine is turned up and allows of a freer escape.

Independent of the solid and liquid excrements of cattle, contained in what is termed cattle-pen manure, of course the vegetable substances thrown into the cattle-pen (both as fodder and litter), and trodden down by the cattle, form a very large proportion of the whole, and must be allowed their value, as matter which will form humus; subject, however, to some very important deductions. These consist chiefly in the deterioration they have suffered during a long period of decomposition, and the ammoniacal impregnation they have received by being in contact with ammonia.

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* Calculated by the number of cattle and mules penned. For instance, if the enclosure or pen be half an acre in extent, and 200 cattle are penned therein for five nights, then five other nights on the next half acre, the land is said to receive 2,000 head to the acre.

Again, when the collected manure has not undergone that protracted process of decomposition, but is applied comparatively fresh, the seeds of the various grasses, weeds &c. &c. eaten by the cattle and dropped in their manure, together with the seeds of the grasses and weeds which have been collected by the planter, and thrown into his cattle-pen to make manure, all spring up in the cane-fields, and give a very great deal of trouble ere they can be eradicated: especially fox-tail grass, bahama grass, and numerous others, which are but too well known to every Jamaica sugar-planter.

The ammonia in cattle excrements speedily evaporates (as carbonate of ammonia), if not fixed; and by so escaping, the very injurious effects which it works in the formation of mucilage, &c. &c. in the cane are prevented, either in part or altogether, according to the proportion remaining; but when clay is thrown into the cattle-pen, or when fly-penning is resorted to on ferruginous soils, the ammonia becomes fixed, and therefore cannot escape. In these cases, the injury to the cane crop is undoubted and excessive, so that good sugar cannot be expected from the "plant canes," and even the first ratoons may be injuriously effected also. But I consider that when no such clay, or other substance possessing similar power, has been intermingled with the excrement; if it be suffered to remain long in the cattle-pen, and is worked up (as I have seen it) so as to expose the interior parts to the air, the greater part of the ammonia will escape, and leave the mass injurious only to the extent of that lesser part remaining.

The gross mixture included under the head of cattle-pen manure, is very similar in character to the farm-yard manure of Europe; which contains when fresh, the following substances:—*

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* See M. Girardin's prize essay on Manures, chapter v.

Water	75
Soluble, vegetable, and animal matters Soluble salts	5
Insoluble vegetable and animal matters Insoluble salts Vegetable fibre and straw	20
	100

Boussingault thus represents the composition of farmyard manure, after six months' (fermentation), which he calls ordinary dung—

Water		79·3
Organic matters	14·03	20·7
Salts and earth	6·67	
		100·0

Whereas this description of dung, when reduced by a long continued fermentation to a pasty brownish-black mass or black butter, has the following composition, according to Boussingault:—

Water	72·20
Organic soluble matter and soluble salts	1·50
Insoluble salts	10·27
Straw converted into peat	12·40
Finely divided peaty matter analogous to the foregoing	3·63
	100·00

Richardson obtained a slightly different result from the analysis of an average specimen of manure, in the state in which it is spread on the land.

Water			64·96
Organic matters			24·71
Mineral matters.	Sand	3·20	10·33
	Soluble salts	1·34	
	Insoluble salts	5·79	
			100·00

M. Girardin goes on to remark, "But if a slight degree of fermentation is capable of destroying the cohesion of vegetable fibre, predisposing it to decomposition, and solution, is useful to manure before spreading it on the land, a long continuance of the same action will prove injurious; as is seen in the heaps of manure on our farms. Under these circumstances, the mass becomes strongly heated, numerous chemical reactions take place, the constituents are completely decomposed, an abundant disengagement of gases takes place, and a dark-coloured liquid is formed. Dung thus loses 25 per cent. of its original bulk, so that a hundred cart-loads of fresh manure are reduced to seventy-five loads. The gases disengaged consist chiefly of carbonic acid, carburetted hydrogen, and ammonia; the useful effects of which are thus lost."

The very valuable effects of ammonia, in the production of wheat and other crops, are well known: but it has been shown that its effects are quite opposite when applied to the sugar-cane; producing very large fine-looking plants, but preventing the deposit of sugar in that abundance which is desirable. It follows, therefore, that the escape of the ammonia contained in cattle-pen manure, should be facilitated by every possible means, when such manure is to be applied in the cane-fields. But the carbonic acid and carburetted hydrogen (a compound of carbon and hydrogen), evolved during the process of "putrefaction" above specified, is a very serious loss, and should be prevented with as much care as the escape of the ammonia is assisted. The planter who uses such manure (to his cane crop) does not require putrefaction to take place in it, although he needs the assistance of the fermentative process; therefore, if he works up his manure frequently, the ammonia will the more speedily be evolved: the fermentative process will not be arrested, whilst the putrefactive will be prevented. Of course, I do not contemplate immense collections of manure, such as have been before alluded to, but moderate quantities; which the planter can without much labour turn up and expose to the air at periods, until the fermentation has reduced the cohesion of the vegetable fibre, and the ammonia has escaped from the mass. These objects will be quickly effected if the manure be frequently worked up; and, as I before remarked, the putrefactive process will be prevented: but, although the ammonia will escape in large quantities, yet there will certainly remain a small quantity entangled in the mass, which will find its way to the roots of the canes, and work mischief in proportion to the extent of that quantity.* Therefore it is that I do not feel inclined to condemn the old practice of planting corn (maize) amongst canes manured with cattle-pen manure: on the contrary (as stated at page 78), I consider much benefit may be derived from it; especially when the leaves and stalks of the corn are moulded into the soil, whilst yet quite green and succulent. The corn plants tend to absorb the ammonia conveyed to the soil in the manure, which they appropriate in the formation of their corn grains or seed, whilst in their decay they furnish the cane with a large supply of humus.

Cattle-pen manure, intended for manuring guinea-grass pieces, cannot, in my opinion, be applied too soon after collection: the process of decomposition should be allowed to take place wholly in the soil, by which a gradual supply of nourishment would be afforded to the grass plants during the whole process, as well as during that of decay (eremacausis) also.

I should not have dwelt so long on this subject, had I not known that, in opposition to all that can be advised against the practice, cattle-pen manure will long be used on West India estates. I have therefore endeavoured to show how the injurious component (ammonia) may be got rid of in part, and the mischievous effect of the remainder, be safely and beneficially diverted. (See *Lime.*)

Human fæces and urine.—From what has already been said, it is evident that this manure must be open to the same objection as that of cattle; only that the former is by many degrees richer and more abounding in ammonia. The fæces contain ammonia, but not in such large quantities as the urine: they are chiefly valuable (for cane-fields) by reason of the phosphates they contain.

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* This also may be prevented by the application of caustic lime to the manure. (See Lime.)

On the continent of Europe, both solid and liquid excrements are collected, and treated, whilst still quite soft, with wood-ashes or other substances containing caustic lime; which deprives them of their loathsome effluvia, and completely expels the ammonia contained in them. In 1846, a most praiseworthy attempt was made in Bridgetown, in Barbadoes, to render these substances available for sugar-cane cultivation, and at the same time to purify the air of the town; which suffered much from the offensive effluvia arising from the night-soil, in the place where it had been deposited. I am not, however, in a position to say whether this meritorious enterprise is still being carried out or not: although it is to be hoped that such is the case.

The parties conducting the operations took the same means of depriving the substance of its fæcal smell, as that practised on the continent: viz., the application of caustic lime; which effected the complete expulsion of its ammonia, and left it with only an earthy smell. It had the name of "Poudrette" given to it, and from frequent trials made with it on cane-fields, it was pronounced to be "a powerful and highly valuable manure."

According to a chemical examination made of this poudrette, it was found to be composed chiefly of phosphate and carbonate of lime, with a little magnesia, silica, and sulphate of lime, and a trace of phosphate of magnesia, sulphate of lime, and lime, in addition to a considerable portion of organic matter. The chemical operator remarking on it, says—"The lime, in the form of carbonate, which is abundant in it, is an addition made in its preparation; and in consequence of this addition, it may be inferred that there is an absence of ammoniacal salts: lime having the property, as is well known, of decomposing all these salts, and of expelling the volatile alkali. But though destitute of ammonia ready formed, it contains in its organic matter the elements of this alkali; thus subjected to destructive distillation, the fluid which came over, mixed with lime, emitted a strong ammoniacal odour."

From this analysis and these remarks, it would appear that the fæcal matter was treated with lime, whilst it was in a perfectly fresh condition; otherwise had fermentation taken place to a degree sufficient to decompose the organic structures, the disunion of their elements would have allowed of the lime acting on them, to the expulsion of the ammonia; for in the continental poudrette the ammonia is entirely expelled (Liebig), which seems to show that the lime was added after fermentation had destroyed its organic parts.*

Human fæces and urine are also much used by the Chinese in the Straits of Malacca, in cultivating the sugar-cane, as well as all other plants. They carefully collect these excrements from every house, and depositing them in a pit or receiver made of brick-work, suffer them to decompose; they then add ashes and common earth, which they thoroughly mix up with them, and apply to their fields and gardens. The practice is so general, that in every Chinaman's garden these receptacles are to be found; and their not using lime or even ashes until the excrement is partially decomposed, is sufficiently evidenced by the offensive effluvia arising from them. In Bengal, human excrements are never used for manure, to the best of my knowledge; but there certainly is no country where the system would be more beneficial, both for the sake of increased crops and purifying the air. The natives of India are, without exception, the very filthiest people in the world, in regard to fæcal matter, which they deposit around their dwellings in the most disgusting manner, so that their villages are offensive in the extreme.

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* The poudrette made in Paris is now mixed with a small quantity of sulphate of iron (copperas) in solution, which deprives the fæcal matter of all smell, by condensing the ammonia as well as the sulphuretted and phosphuretted hydrogen, which together produce the characteristic effluvia. This salt acts on the ammonia by its acid, and on the gases by its oxide: thus the most noisome cesspools may be rendered almost entirely inodorous.

Nor is this confined to villages alone; for even in and about Calcutta, the rides and drives are horribly polluted in the same manner; but especially the principal carriage drive along the "Strand" (the Hyde Park of Calcutta), which I have known to be so unbearable at times, that I could not pass without being obliged to use my handkerchief. This arises from the numerous budjerows, bowleos, and boats of all descriptions which are permitted to *leegao* between Chandpaul ghaut, and the fort; the boatmen belonging to which, together with numerous other persons, are constantly committing this disgusting nuisance.

The quantity which might be collected in Calcutta (without any trouble whatever) is quite incredible, and if treated with caustic lime to expel the ammonia, might be made available for sugar-cane cultivation; or if with burnt clay, gypsum, or other substances to fix the ammonia, then for wheat and other crops requiring a large supply of nitrogen. There is only one caste amongst the natives who I know can be induced to undertake the office of nightmen; this is the "Mehta caste," whose proper employment it is.

There are others, such as the Dhomes, Pariahs, Chumahs, and the Dhanghers, who might, and perhaps do, perform such work about Calcutta; although I am not aware of the fact.

From what has been said on the subject, it is apparent that, to convert human excrements into a manure desirable for the canes, the ammonia contained must be wholly expelled; which is quite easy of accomplishment.

Guano.—There does not appear to me to be any substance, concerning which more contradictory and incorrect accounts have been given, than of the celebrated manure known as guano.

Humboldt says,—"During three hundred years, the coast birds have deposited guano only a few lines in thickness.

This shews how great must have been the number of birds, and how many centuries must have passed over, in order to form the present guano beds."

Dr. Ure and almost every other writer on the subject have adopted the idea of guano being entirely an excrementitious deposit; and in consequence, many very curious calculations have been made, with a view to show how many centuries must have elapsed during the accumulation of the great guano beds.

But from testimony which I am about to adduce, it is very evident that these notions are absurd and ludicrously incorrect.

In 1845, an enterprising mercantile firm despatched a vessel to the west coast of Africa, to search for nitrate of potash, which was said to exist there in large quantities. This being a valuable substance, the owners also engaged the professional services of Mr. T. E. Eden, jun., (a member of the college of surgeons in London) in order that the enterprise might not fail for lack of proper chemical knowledge. This gentleman, although he did not discover nitrate of potash which) in all probability never existed there) yet has presented the public with a very interesting and well written work, detailing some of the particulars relative to the expedition, and giving a highly satisfactory account of the substance denominated guano.*

I have much pleasure in introducing extracts from his work, descriptive of the facts which presented themselves to his observation; feeling confident that the account he gives of guano, will prove acceptable to my readers. He says—

"Having left England under the common impression that guano was the dung of birds, when I first saw this substance (cake guano) I concluded that I had at last discovered the veritable guano, and that I should find in it a large quantity of uric acid; but as, upon analysis, it was found to be composed chiefly of phosphate of lime, the idea which I had taken was not admissible." * * * *

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* When no nitrate of potash could be found, the vessel took in a cargo of guano.

"At Ichaboe, the surface of the rock was covered in some places with masses of decomposed sea-shells; which, however, contained some ammonia, and formed part of the last cargoes which had been taken from that island. The shells appear to be of an existing species of bivalve. Masses of these decomposed shells were also found on the islands of Angra Pequena. This deposit exists more or less at the bottom of the guano on all the islands which I have visited." * * * * * * * *

"There can be no question that the excrement of birds enters partly into the composition of guano, but it forms a very small proportion. I saw on one occasion a film of a beautiful pink colour (purpuric acid?) upon the surface of the rock, but it was not in sufficient quantity to be collected, and I have not been able to procure any appreciable quantity of uric acid in the analysis of guano." * * * * * *

"The birds do not produce so bulky an excrementitious deposit as the birds of our own islands, and their dung cannot be separated from the other constituents of guano. Such being the appearances which presented themselves to me, on my visit to the guano islands, my preconceived notions became entirely changed, and I no longer regarded this product as entirely excrementitious, but as composed of the carcasses of numerous birds and seals, which either live and die on the islands, or visit them for the purposes of propagation and food. In the natural history of these birds and animals, therefore, is to be found the true source of this valuable product. It is probable that the first deposition is composed principally of seals and penguins: these animals possessing greater powers of locomotion in the water than on land, are led to prefer the shelving and the lowest parts of granite islands; gannets and shags may also be associated with them, at the same time preferring the higher rocks of the same island. After the lapse of many generations of these animals, and when an island has become elevated from the continual accession of their remains, it is easy to conceive that it will be no longer convenient or accessible for seals, and perhaps for penguins; after which the future accumulations will consist entirely of the remains of winged birds. It is also probable, from some peculiarities in their habits, with which I am not acquainted, that birds themselves will forsake the guano islands, when the mass has obtained any considerable elevation. This I am informed is the case on the Peruvian coast, where the guano, being in some places as much as three hundred feet in thickness, is no longer frequented by birds. It is to be hoped that their burial grounds may be speedily cleared, that they may renew their valuable deposits.”

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“The following are the ingredients which enter into the formation of guano:—water, animal matter—

Phosphoric, sulphuric, muriatic	Mineral acids.
Uric, oxalic, carbonic	Organic acids.
Ammonia, potash, soda	Alkaline.
Lime, magnesia	Alkaline earths.
Silica, alumina	Earths.

Upon each of which it will be necessary to make a few remarks. Water, as it relates to guano, must be considered in three ways—First, that resident in the bodies of all animals; second, that of the atmosphere; and third, that which falls as rain.[*] If this last be too abundant, the valuable products will be washed away; if moderate, the decomposition will go on more or less rapidly: depending upon the quantity which falls, and in some measure upon the age of the guano, or the time it has been deposited and subject to the decomposing action. Morrell states in his account of Possession Island, that there appeared to have been a plague or murrain among the seals, as the island was covered with their dead carcasses. When we were there, after the lapse of seventeen years since Morrell's voyage, these seals (supposing them to be the same) were not so much decomposed but that their fur was distinguishable, and was shipped in large quantities by many of the vessels. The decomposition continues to progress in the ship's hold, when the guano is very damp. That which we obtained, though giving a slightly acid solution in water, and having very little smell of ammonia when first shipped, upon our arrival at St. Helena, gave off so much as to produce tears, and a difficulty of breathing upon descending the hatchway. This, however, in a great measure disappeared during the passage; but I still observed that the smell was much stronger on a damp night than on a dry one. The fur shipped from the island is said to have become converted into powder before reaching England."

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[*] Abbreviated.

Animal matter is a most valuable ingredient in guano, and the source from which many of the others are derived. It shows, indeed, that the guano has still to undergo further changes, and that the proximate principles of the animal bodies are not yet entirely converted into the chemical principles: but these changes will probably take place* in the soil, through the agency of plants. All the ammonia and organic acids are derivable from it, and the proportion of latent ammonia will entirely depend on it. I have found as much as 12 per cent. of animal matter, precipitable by acids (albumen?) in the soluble portion of the guano of Possession Island, besides some which was not so precipitable, and was probably gelatine.

Phosphoric acid (*biphosphate of ammonia*), of the mineral acids, is the most abundant and most important in animal bodies, entering largely into the formation of the bones. The nervous matter of animals has been long known to contain phosphorus; it is important as forming in itself the food of plants, and as producing, with ammonia, a salt least liable to become decomposed and removed in a moist climate. I have generally found it in a state of acid biphosphate of ammonia, and composed as follows :—

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* See on this subject the extracts from Liebig, already given, on Fermentation, Putrefaction, and Decay or Eremacausis.

				Per cent.
1 equivalent of	phosphoric acid	71·4	=	61·79
1 ,,	ammonia	17·15	=	14·84
3 ,,	water	27·	=	23·37
		115·55		100·

At Hollam's Bird Island, this salt, having been dissolved by the dews and mists, had filtered, as it were, through the guano, and had become crystallized through its substance, but most abundantly at the bottom. It is very soluble in water, but if not washed away is a most permanent salt, and not likely to be dissipated by the air. I have found it to be also the most abundant compound of ammonia in African guano. Its presence in skulls and bones is exceedingly curious and instructive, especially in the cavities of long bones; for since marrow does not contain nitrogen, the ammonia of the salt cannot be derived from that source. Possibly the animal matter of the bone has undergone some change, whereby the ammonia has been formed, and the phosphoric acid has been taken away from the bone itself, as the bones containing it are generally in a decomposing state.

Phosphate of lime.—Phosphoric acid is also in union with lime. This salt forms the principal part of the bones of animals, and, according to the analysis of all chemists, of every description of guano also. It does not form so valuable a manure as biphosphate of ammonia, but more so than ground bones, which are much employed in many soils. It is composed of—

8 equivalents of	lime	228·
3 "	phosphoric acid	214·2
		442·2

The large amount of phosphorus necessary for the formation of these salts, is derived by the seals and birds from the fish on which they feed. The waters of the ocean on this coast are very phosphorescent, and the sea would frequently break over the island, during a dark night, like a sheet of fire.

Phosphate of soda and ammonia is found abundantly at Possession Island, in rhombic octohedral crystals, mixed up with the hair of the seals; and also at the bottom of the guano at Hollam's Bird Island, in association with crystals of biphosphate of ammonia. It is a very valuable constituent of guano, and consists of—

			Per cent.
1 phosphoric acid	71·4	=	35·75
1 ammonia	17·15	=	8·17
1 soda	31·3	=	10·63
10 water	90·0	=	45·45
			100·

Phosphate of ammonia and magnesia, in union, form another double salt; which, being almost insoluble, is united with phosphate of lime and animal matter, to constitute the insoluble part of guano. It also forms glittering crystals in the stone or cake guano, which has not been much exposed to sea-water. Its composition is as follows:—

			Per cent.
1 phosphoric acid	71·4	=	30·11
2 ammonia	34·3	=	10·23
1 magnesia	41·4	=	17·46
10 water	90·0	=	42·20
			100·

Sulphuric and muriatic acids are present in small quantities in animal structures, and likewise in sea-water. In guano they are generally combined with the fixed alkalies, as potash, soda, &c. Common salt (chloride of sodium) is frequently deposited in much abundance by the evaporation of salt water, with which the guano has been intermingled; but this can only be the case at those islands which are washed by rollers, or whose slight elevation and peculiar construction induce the formation of spray.

Uric, oxalic, and carbonic acids.—These three organic acids are formed from the animal matter, being composed of the same ultimate constituents in variable proportions. They have the faculty of passing from one to the other as the decomposition advances. Thus uric acid, a fixed and insoluble product, so long as it remains such, under favourable circumstances undergoes various changes, and gives rise to volatile and soluble products, one of which is carbonate of ammonia. Oxalic acid is also prone to be resolved into carbonic acid. The principal and most important agent in the production of these changes appears to be water, for which reason guano deposited in a dry climate is so much to be preferred. I have made several attempts to discover uric acid in the guano of Possession Island, but without success.

Ammonia is considered the most valuable ingredient in guano; the salt which is most permanent in a moist climate is the biphosphate; but the urate of ammonia is by far superior, on account of its comparative insolubility, and also because the uric acid yields a large quantity of ammonia by its decomposition in the soil, in addition to that with which it is chemically combined. Carbonate of ammonia is found chiefly in damp guano; it is perhaps the least valuable of the salts of ammonia, on account of its volatility. The smell which guano naturally possesses arises from the escape of this salt; but though guano with a strong smell is usually preferred, it is not, by any means, a good criterion. That which has no smell will often be found to contain a much larger quantity, combined with such acids as prevent its volatilization. A much better test of the quality of guano is to mix with it some caustic, potash, or lime, which, uniting with the acids, sets the ammonia (present) free.

Potash and soda are occasionally united with mineral acids, but in small quantities; their salts, therefore, do not enter extensively into the composition of guano.

Lime is sometimes combined with oxalic acid in the insoluble portion, and mixed with phosphate of lime; but I believe it is much more frequently present as a carbonate.

Magnesia may be found in combination with phosphoric acid and ammonia.

Silica and alumina are present in the remains of animals only in minute quantities, and in this point of view are of no importance in the composition of guano. But guano islands which are situated in close proximity to a sandy coast, are likely to become impregnated with particles of sand, which, being wafted by the wind, contaminate the guano, sometimes to a considerable extent. Sand does not appear to be used by the guaniferous birds for the purpose of triturating their food; they seem to be provided with a thick membranous stomach, far less muscular than the gizzard of land birds. The granite pebbles swallowed by seals for the purpose of ballasting them, are found dispersed through masses of seal guano. I have endeavoured to direct attention to guano, principally with a view to elucidate the phenomena which presented themselves to me, and I hope sufficient has been said to remove every doubt "that guano is not formed exclusively by the dung, but chiefly by the carcasses of birds and seals."

Such is Mr. Eden's highly interesting account of guano (which I have taken the liberty of abbreviating in many places, in order to suit these pages), and I think with him, that no doubt can be entertained as to the origin of the great guano beds, both Peruvian and African. Captain Morell says, "On the surface of this island (Possession Island, September 1828), I saw the effects of a pestilence or plague, which had visited the amphibious inhabitants of the ocean with as much malignity as the Asiatic cholera has the bipeds of the land. The whole island was literally covered with the carcasses of fur seal, with their skin still on them. They appeared to have been dead about five years, and it was evident that they had all met their fate about the same period. I should judge, from the immense multitude of bones and carcasses, that not less than half a million had perished here at once; and that they had all fallen victims to some mysterious disease or plague. * * * These two islands (at Angra Pequena) have once been the resort of immense numbers of fur seal, which were doubtless destroyed by the same plague which made such devastation amongst them on Possession Island, as their remains exhibited the same appearance in both cases. Shags and penguins had now taken entire possession of the islands."—*Morrell's Narrative.*

I have every reason to believe the above account to be correct, as it has been corroborated by the testimony of several old ship masters; otherwise, I would not have ventured to bring forward the writings of so notorious a Munchausen as Captain Morrell. Indeed, the very facts mentioned by Mr. Eden go far to prove the truth of an extraordinary devastation having really at some former period taken place amongst the seals frequenting those islands. Besides which, it is well known that Morrell's Narrative contained (amidst a mass of the grossest fiction) many very singular facts, which later events have proved beyond dispute to be well founded.

Dr. Ure gives a very long and interesting account of guano, together with numerous analyses of both Peruvian and African; as an average of all which, he presents us with the following analysis of genuine guano, in reference to its agricultural value—

1. Azotised animal matter, including urate of ammonia, together, capable of affording from 8 to 16 per cent. of ammonia by slow decomposition in the soil	50
2. Water	8 to 11
3. Phosphate of Lime	12 to 25
4. Phosphate of ammonia, sulphate of ammonia, ammonia, phosphate of magnesia, together, containing from 5 to 9 parts of ammonia	13
5. Siliceous sand	1
	100

It is quite evident from this analysis and all the foregoing statements, that guano, when fresh and good, contains a very large amount of ammonia; which, as I have already frequently said, is quite unsuitable for sugar-cane cultivation. Guano, therefore, must be regarded as highly injurious to the formation and deposit of sugar in the cane-plant, and as such we cannot but pronounce it to be a manure which no sugar-planter should use. Having, notwithstanding such conviction, given this very lengthy account of this substance, it only remains for me to say, that its use is strongly recommended to the sugar-planter by many very celebrated names, amongst whom that distinguished chemist Dr. Ure stands conspicuous. In the supplement to his learned and very useful work, "The Dictionary of Arts and Manufactures," he says, "To the West India planter, guano will prove the greatest boon, since it condenses, in a portable and inoffensive shape, the means of restoring fertility to his exhausted cane-fields; a benefit it has long conferred on the poorest districts of Peru."

Now, with a recommendation such as this, we cannot wonder at many planters trying the virtues of guano on their cane-fields; backed as it has been by many others. But, apart from the learned celebrities of Europe, I find many of the Elgin Treatises, written by Jamaica planters, strenuously upholding guano and every other substance containing ammonia. Indeed, the prize of 100*l.* was awarded to an essay, which, amongst its numerous errors, upheld this anent the usage of ammoniacal manures; whereas the essay* (in every way excellent) of Mr. Whitehouse was passed over.

I am free to confess, that in a small work on sugar, printed in the East Indies in 1843, I committed the same mistake;

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* In 1846, I had the honour of receiving from the Royal Agricultural Society of Jamaica this excellent essay, together with the others; and at same time the secretary was kind enough to present me with Agricola's Tropical Agriculture, also by Mr. Whitehouse, in whose death the planters have sustained a very great loss.

and it was not until some months afterwards that I became convinced of my error.

Knowing all this, and believing that there are a great number of planters still unconvinced of the pernicious effects of guano on canes, and who will consequently continue to use it,* I have entered at length on the subject, and can only strenuously advise them not to use it in their cultivation.

There is another kind of guano in the Straits Settlements known as "bat's dung guano," which is collected in the islands of and about Junk Ceylon, but a short distance from Penang. It is used by the proprietors of nutmeg plantations for their spice trees; and I have seen it applied by some sugar-planters to their canes: but it is not a desirable manure for sugar-canes by any means. The natives manufacture from it large quantities of saltpetre, &c.

Bones are now much used in agricultural operations, and are known to exercise a most beneficial influence on vegetable life; but they differ very much in their constituents, according to the state they are in, when subjected to the crushing process. Thus, fresh bones are considered as being composed of one-half animal matter, and the remainder of phosphates of lime and magnesia, and carbonate of lime. In this state they are crushed to a fine powder, and applied to land, either directly as phosphates or treated with sulphuric acid, by which phosphoric acid is formed.

Liebig says,—"Manuring an acre of land with 40 lbs. of bone-dust is sufficient to supply three crops of wheat, clover, potatoes, turnips, &c. with phosphates. But the form in which they are applied does not seem to be a matter of indifference; for the more finely the bones are reduced to powder, and the more intimately they are mixed with the soil, the more easily are they assimilated. The most easy and practical mode of effecting their division, is to pour over the bones (in a state of fine powder) half their weight of sulphuric acid, diluted with three or four parts of water, and after they have been digested for some time, to add one hundred parts of water, and sprinkle this mixture over the field before the plough. In a few seconds the free acids unite with the bases contained in the earth, and a neutral salt is formed in a very fine state of division."

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* In a speech of Sir Chas. Grey, Governor of Jamaica, he thus alludes to the quantities of guano used in Jamaica. "The waste which is everywhere observable in this neighbourhood of the materials of agricultural manures, and *the large sums which are expended in guano,* make me wish to direct your attention to the practicability of producing equivalent combinations by methods which chemistry points out." (Extract of speech to the Royal Agricultural Society of India.)

Dr. Ure says,—" The easiest means of procuring the earthy salts of bones, consists in burning them to whiteness; but the earthy residuum procured in this manner contains substances which did not exist beforehand in the bones, and which did not form part of their earthy salts: as, for example, sulphate of soda, produced at the expense of the sulphur of the bones and the alkaline carbonate proceeding from the cartilage with which it was combined. On the other hand, the greater part of the lime has lost its carbonic acid. The phosphate of lime contained in the bone-salts is a sub-phosphate, consisting, according to Berzilius, of three prime equivalents of the acid and eight of the base."

In England, from twenty to forty bushels of ground bones are applied to one acre, and some discrimination is necessary in fixing on the soil whereon their application is likely to prove beneficial. It must be remembered that they are only required in a *cane*-field when it is deficient in phosphates, without which the plants could not thrive; but many very dry bones contain a considerable quantity of animal matter, which they lose when subjected to the boiling process (so common in England) previous to being ground into powder for manure. Almost all the bone-manure which has been sent to the West Indies had previously undergone this process, and had consequently been deprived of the animal matter which was contained in them. Liebig tells us that "one hundred parts of dry bones contain from 32 to 33 per cent. of dry gelatine, supposing which to contain the same quantity of nitrogen as animal glue, viz., 5·28 per cent., then one hundred parts of bones must be considered as equivalent to two hundred and fifty parts of human urine." Thus we find that fresh bones contain nitrogen in large quantities, which, whilst decomposing in the soil, is converted into carbonate of ammonia and other ammoniacal salts; so that cane-plants treated with this manure are powerfully affected, not only by its phosphates, but also by its nitrogen. It is very necessary, therefore, to notice very attentively this distinction betwixt bones that have had all this animal matter boiled out of them, and fresh bones which still contain this source of nitrogen. Bones that have been burnt to ashes lose their gelatine and become earthy salts: which, however, have the property of absorbing a considerable volume of ammoniacal gas; but this power once exercised cannot be repeated when the bone-ashes have been applied to the soil. Fresh bones which have been reduced to powder and placed in heaps require but a slight degree of moisture to generate heat and enter into putrefaction; but although their gelatine is thereon decomposed, and its nitrogen converted into ammoniacal salts, yet the powder has still the power of retaining a great proportion of them in itself. (Liebig) Bone-manure is more especially recommended in England for light, sandy, or gravelly soils, rather than for clay-soils, which distinction would apply in tropical countries. But this manure is never required in large quantities on any soil, as 40 lbs. of it is sufficient to enable an acre of land to furnish phosphates to three crops of wheat.

When the cane-trash is burnt as fuel on an estate, it becomes highly necessary to manure with bone-dust or bone-ashes, in order to supply the soil with phosphates; but when such is not the case, no manure of the kind is required.* Bone-ashes would, in my opinion, be the best form in which to use bones as a manure for sugar-cane fields.

Marl offers the planter one of the safest and readiest means of manuring his lands that I know of; but I am very much afraid it is not so much used as it should and might be. There are many situations where marl is not obtainable; but on the other hand there are numerous localities in which it can be procured in any quantity, for the mere trouble of digging it and carting it out to the fields. Marl differs very much in its colour, general appearance, and fertilizing virtues: the better descriptions are of a white or slate-blue colour, and are soft and unctuous. The constituents of the former are carbonate of lime, with lesser parts of alumina, silica, and bitumen; of the latter, carbonate of lime, with albumen, iron, and bitumen.

In treating of marls, it is usual to class them as calcareous, clayey, or sandy, according to the preponderance of lime, clay, or sand; and the relative value of each depends entirely on the nature of the soil, to which it is to be applied. Thus, in a clay-soil, a sandy marl would be highly beneficial; and in a sandy soil, a clayey or calcareous marl.

In Jamaica, marl is to be had in vast quantities in many parts of the island, and would be of great benefit to the sugar estates; but I cannot say that I have seen it used there except in rare instances: which is the more censurable when we consider the expense and trouble many planters are at in getting manures from England, whilst this excellent substance is immediately at hand, and in such great abundance. Bryan Edwards, in his excellent work on the West Indies, endeavoured to attract the attention of the planters to this fertilizer, and Porter also did the same. Edwards said, "Marl is another manure of vast and general utility in Great Britain. It enriches the poorest land, opens the stiffest, and sweetens and corrects the most rank. Lands have been raised by the use of this manure from two shillings per acre to a guinea, annual rent. Now, there is no country under the sun, wherein a soft unctuous marl more abounds than in Jamaica."

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* Where cane-trash is burned as fuel, and the ashes are applied to the cane pieces, the phosphates are therein returned to the soil, (see Ashes of Cane-trash.)

This was written a very great many years ago; but I do not believe that this excellent advice has been followed: except only very partially. In the Straits Settlements, a blue marl of very rich quality is exceedingly abundant, which I have long used every persuasion to induce planters to avail themselves of; and in one or two cases successfully. This marl abounds in a kind of petroleum or earth oil, which plentifully exudes from it. It is found in every part of Province Wellesley, Singapore, and Malacca, only a few feet below the surface of the (low) land.

When exposed to the air for a short time it dries, and becomes a fine friable substance, in which state it is advisable to apply it to fields, or even growing canes; but, if carted out to land prior to canes being planted, it can be spread in the condition in which it is dug, when a week's (or ten days') alternate sun and rain will cause it to crumble into a pulverulent mould, which should then be ploughed into the soil and well intermingled. I also found that by being dried and then burnt, it afforded a very rich manure, which affected very favourably the cane-plant. Mr. Wilson, a very intelligent planter in Province Wellesley, tried it in several instances, at my suggestion, and was entirely convinced of its complete adaptation to the cane as a manure of highly fertilizing virtue.

In many parts of India (Bengal), also, fine rich marls occur: these should always be regarded by the planter as a very great advantage, which ought to be availed of whenever manure is required.

Liebig tells us that all marls contain a certain quantity of potash.

Clay is widely diffused throughout all countries: no planter can therefore have any difficulty in procuring a supply if he wishes it.

Clay is merely two simple earths—alumina and silica—tinged with iron and other minerals; it is a great absorbent of moisture, which it retains with great tenacity, even under very trying degrees of heat: hence its great value in seasons of very dry and hot weather. In light sandy lands, the application of clay is eminently useful in strengthening and binding the soil; in fact, it has the essentials to convert a barren sandy field into a rich and productive one.

We generally view clay as a manure only in relation to its value in binding a light sandy soil, and in enabling a soil to attract and retain moisture from the atmosphere; but Liebig has proved that its great fertilizing influence consists in its absorbing and fixing in the soil the ammonia of the atmosphere. He says, "The advantage of manuring fields with burnt clay, and the fertility of ferruginous soils, which have been considered as facts so incomprehensible, may be explained in a very simple manner. They have been ascribed to the great attraction for water exerted by dry clay and ferruginous earth; but common dry arable land possesses this property in as great a degree. * * * * *

"The true cause is this:—The oxides of iron and alumina are distinguished from all other metallic oxides by their power of forming solid compounds with ammonia. The precipitates obtained by the addition of ammonia to salts of alumina or iron, are true salts, in which the ammonia is contained as a base. Minerals containing alumina or oxide of iron also possess, in an eminent degree, the remarkable property of attracting ammonia from the atmosphere, and of retaining it. * * * * Soils, therefore, which contain oxides of iron and burnt clay must absorb ammonia: an action which is favoured by their porous condition; they further prevent the escape of the ammonia, once absorbed, by their chemical properties. * * * * The ammonia absorbed by the clay, or ferruginous oxides, is separated by every shower of rain, and conveyed in solution to the soil."

The application of clay to land, although it may properly be treated of under the head of manure, is, more correctly speaking, the formation of a soil; especially where the quantity used is very large. For instance, a very sandy piece of land, which we could not think of planting canes in, may be so situated with regard to the works, that its being converted into a good substantial soil might become an important object; the course, then, is not merely to manure it, but to change its entire character, by carting to it a quantity of clay sufficient to convert it into a light brick mould.

The trouble and expense may be considerable as a first outlay, but then the effects are lasting; and the land so treated may be looked on as a good, fertile, and improving soil, which will continually produce canes. But when we use clay in small quantities only, it more deservedly comes under the designation of manuring: as when we require to strengthen a light soil so as to render it retentive of moisture, or to use burnt clay in order to attract the ammonia to the atmosphere.

All ferruginous clays have the power of attracting and fixing in the soil the ammonia of the atmosphere; but when burnt, this property is very greatly increased. I have several times said that nitrogen is necessary to plants, and that it exists in the atmosphere in the form of ammonia; but ammonia, wherever and however existing, contains nitrogen in the proportion of 65 lbs. of the latter to 80 lbs. of the former (Liebig). Now, although this substance is absolutely necessary to the growth and full development of the cane-plant, yet (as I have often observed) too large a quantity applied to the soil, in the form of manure, has the effect of inducing the cane to form mucilage, gluten, &c. &c.; instead of depositing sugar in its cells, as it does when the supply of nitrogen is limited.* If canes be manured with their own trash, or with an adequate proportion of vegetable matter, there can be no doubt but the humus resulting will attract and furnish to the cane-plants quite sufficient nitrogen to produce a fine and saccharine cane, without the aid of any other manure. But where this is not the case, as may occur in very light soils, no means can be adopted to supply the deficiency more readily, more cheaply, and more safely, than by treating the land to clay, either in its natural condition or after it has been burnt. I infinitely prefer this mode of assisting a soil to that proportion of nitrogen which is desirable, to the application of ammoniacal manures. The former affords the means of ensuring a gradual and perfectly regulated supply, which the latter by no means does; for, by the application of a certain quantity of burnt (or unburnt) clay on an acre of land, we confer on that field the power of attracting and fixing in its soil the (ascertained amount of) ammonia, of which that quantity of clay is capable. But to enable it to exercise this power to its fullest extent, it is necessary that the weather be seasonable, and the soil sufficiently porous: in seasons of a uniform character, its action is also uniform and continual; subject only to the change caused by the abstraction of the metallic oxides contained in the soil by the plants grown on it. Thus, a planter giving his lands (light soils) a few pounds of burnt clay, may feel assured that those lands will thereby

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* A superabundance of carbon in the state of carbonic acid conveyed to the roots of plants, without being accompanied by nitrogen, cannot be converted either into gluten, albumen, wood, or any other component part of an organ; but either it will be separated in the form of excrements, such as sugar, starch,

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oil, wax, resin, mannite, or gum, or these substances will be deposited in greater or less quantity in the wide cells and vessels. The quantity of gluten, vegetable albumen, and mucilage will augment when plants are supplied with an excess of food containing nitrogen; and ammoniacal salts will remain in the sap, when, for example, in the culture of the beet, we manure the soil with a highly nitrogenous substance, or when we suppress the functions of the leaves, by removing them from the plant. * * * We know that the quantity of starch in potatoes increases when the soil contains much humus, but decreases when the soil is manured with strong animal manure; although then the number of cells increases, the potatoes acquiring in the first case a mealy, in the second a soapy consistency. Beet-roots taken from a barren sandy soil contain a maximum of sugar, and no ammoniacal salts; and the Teltowa turnip loses its mealy state in a manured land, because there all the circumstances necessary for the formation of cells are united.—*Liebig*, p. 133.

obtain a supply of ammonia for many years: indeed, until the metallic oxides are removed from the soil; which would require a great lapse of time to bring about. In fine ferruginous soils, of course no such application can be needed, as the power already exists, and is in continual action.

Other substances, mentioned in the table of manures, also afford the means of establishing in the soil a supply of ammonia: such as charcoal and gypsum; but the causes which operate are very different in the three substances. Clay has been shewn to act by the metallic oxides contained in it. Charcoal certainly attracts and fixes, by its own peculiar properties, both ammonia and carbonic acid; but the cause of this action cannot be stated, beyond ascribing it to the wonderful laws of affinity. Gypsum is composed of sulphuric acid and lime; hence, on being applied to the soil, its decomposition gradually takes place by the ammonia (in the soil, air, or rain water) entering into combination with the sulphuric acid, and the carbonic acid with the lime, forming compounds which are not volatile.

Charcoal, when properly burnt, is so indestructible a substance, that it will keep without perceptible change for ages; but when carelessly prepared (especially some descriptions made from fir wood), it is asserted that it decomposes and becomes a kind of coally humus. Lucas says, "There can scarcely be a doubt also that (the) charcoal undergoes decomposition; for, after being used for five or six years, it becomes a coally earth; and if this be the case, it must yield carbon or carbonic oxide abundantly to the plants growing in it, and thus afford the principal substance necessary for the nutrition of vegetables. * * * It exercises likewise a favourable influence by decomposing and absorbing the matters excreted by the roots, so as to keep the soil free from the putrefying substances which are often the cause of the death of the *spongiolæ*. Its porosity, as well as the power which it possesses of absorbing water with rapidity, and, after its saturation, of allowing all other water to sink through it, are causes also of its favourable effects."

This authority treats the actual decomposition of charcoal as a matter fully proved by a series of experiments carried out by him during several years: but, according to Liebig, the "coally humus" found by Lucas, resulted from the excretions of the plants themselves, not from the charcoal. We can readily understand how peculiarly favourable the powder of charcoal is to the decomposition of (organic) excrementitious matter deposited by plants growing on it; as charcoal powder has the power of separating the carbonic acid and ammonia contained in water and air, placing the oxygen of both in a state of greater freedom to act on the organic matter and convert it into humus; whilst its porosity presents the most favourable condition for an unobstructed continuance of those actions.

Liebig says "Common wood-charcoal, by virtue merely of its ordinary well-known properties, can completely replace vegetable mould or humus. * * * Plants thrive in powdered charcoal, and may be brought to blossom and bear fruit, if exposed to the influence of the rain and the atmosphere: the charcoal may be previously heated to redness. Charcoal is the most indifferent and most unchangeable substance known; it may be kept for centuries without change, and is therefore not subject to decomposition. The only substances which it can yield to plants are some salts which it contains, amongst which is silicate of potash. It is known, however, to possess the power of condensing gases within its pores, and particularly carbonic acid. And it is by virtue of this power that the roots of plants are supplied in charcoal exactly as in humus, with an atmosphere of carbonic acid and air, which is renewed as quickly as it is abstracted. In charcoal powder, which had been used for this purpose by Lucas for several years, Buchner found a brown substance soluble in alkalies. This substance was evidently due to the secretions from the roots of the plants which grew in it."

Charcoal therefore is proved to be as highly valuable a substance as manure; and it may, with safety and great benefit, be used by sugar-planters for their canes. In some parts, where the scarcity of wood-lands renders the cost of charcoal expensive, other substances may be used to produce a similar effect; but wherever it can be procured cheaply, it should certainly be adopted.

In various parts of India, in the Straits Settlements, and in many parts of the West India Islands, immense abundance can be procured at a merely nominal price; for instance, in the district of Goruckpore (where there are large tracts of jungle), I could at any time command a supply of any extent, at the rate of seven rupees (about 14*s.*) the hundred maunds (of 100 lbs. each) equal to about four and a half tons.

This certainly is very cheap, and in other situations not so favourably situated, of course it would be much dearer; but in the Straits Settlements charcoal can be burned in the woods* belonging to each estate, at a cost very little exceeding that named,—*id est*, charcoal suitable for manuring. But whether the cost be great or little, it is necessary for the planter to remark, that the fertilizing effects of charcoal will last as long as the charcoal itself lasts: which may be reckoned as many ages. In applying it to land, it is advisable to do so in the state of a coarse powder. Liebig states charcoal to be particularly valuable on heavy soils, particularly such as consist of argillaceous earth; and it is plain that in vegetable mould, or in soils abounding in humus, it is unnecessary and undesirable. I know of no manure of which an East Indian planter can avail himself, so cheap and so beneficial as charcoal; it supplies the place of humus, furnishing to plants both carbonic acid and nitrogen, and compensates better than any other substance for the complete stripping which the land but too often receives, in applying the leaves as fodder for cattle, the trash as fuel, and not even using the cattle-dung as manure.

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* I must not be understood to mean by the very wasteful and absurd plan pursued by the Chinese, but by the common Indian mode of burning in holes dug in the ground, wherein the wood is carefully placed, and then covered over with earth, clay, &c. &c. These holes are dug wherever the wood is cut up, and are very simple affairs.

Gypsum has already been mentioned as one of the substances, by which the planter can safely supply to his canes the ammonia which may be found wanting in his fields; but the lasting effect is merely temporary in comparison with that of charcoal and clay. It is a very powerful attractor of ammonia, and its action on soils is explained by Liebig in his usual interesting and simple manner. "The evident influence of gypsum upon the growth of grasses, the striking fertility and luxuriance of a meadow whereon it is strewed, depends only upon its fixing in the soil the ammonia of the atmosphere, which would otherwise be volatilized with the water which evaporates. The carbonate of ammonia contained in rain-water, is decomposed by gypsum, in precisely the same manner as in the manufacture of sal-ammoniac. Soluble sulphate of ammonia and carbonate of lime are formed, and this salt of ammonia, possessing no volatility, is consequently retained in the soil. All the gypsum gradually disappears, but its action upon the carbonate of ammonia continues as long as a trace of it exists. * * * The action of gypsum or chloride of calcium really consists in their giving a fixed condition to the nitrogen or ammonia, which is brought into the soil, and which is indispensable for the nutrition of plants. In order to form a conception of the effect of gypsum, it may be sufficient to remark that one hundred Hessian pounds (about 110 lbs. English) of burned gypsum fixes as much ammonia in the soil as 6,250 lbs. of horses' urine* would yield to it;

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* The urine of the horse contains, according to Fourcroy and Vauquelin, in one thousand parts—

Urea	7	parts.
Hippurate of soda	24	,,
Salts and water	979	,,
	1,000	parts

even on the supposition that all the nitrogen of the urea and hippuric acid were absorbed by the plants without the smallest loss, in the form of carbonate of ammonia. * * Water is absolutely necessary to effect the decomposition of the gypsum, on account of its difficult solubility (one part of gypsum requires four hundred parts of water for solution), and also to assist in the absorption of the sulphate of ammonia by the plants; hence it happens that the influence of gypsum is not observable on dry fields and meadows. The decomposition of gypsum by carbonate of ammonia does not take place instantaneously; on the contrary, it proceeds very gradually, and this explains why the action of gypsum lasts for several years."

In England this manure is very much used, and is considered a powerful fertilizer in crops of grasses, lucerne, red clover, and sainfoin; but latterly it has been much out of repute in regard to the common corn crops. It is generally recommended to the farmer, to spread it on his land in a finely powdered state, at the rate of from two to three cwt. per acre; and is sold commonly at thirty shillings a ton. The application of gypsum to *cane* lands requires to be nicely regulated, so as to afford to the cane just that quantity of ammonia which is desirable, and no further: but enough has already been said to direct the planter how, and in what cases, to use such kinds of manure.

Lime is a well-known and very powerful fertilizer of land, and is particularly valuable on soils affected by sulphate of iron, sulphuric acid, and other acids injurious to vegetation, as mentioned at page 41. Applied as manure on such land, lime at once enters into combination with the sulphuric or other acid, and thus counteracts its evil influence. Lime forms a part of every fertile soil; it is one of the great constituents of aluminous earths, and indeed of almost every manure I have enumerated. It exercises a very beneficial influence on the growth of sugar-canes, and affects very desirably the quality of the sugar made from canes manured by it. In a rank vegetable soil, such as newly cultivated jungle land, it is of infinite service, not only for the immediate results, but also from the enduring influence of its combinations. Strewed in the cattle-pen occasionally during the formation of the cattle-pen manure, or applied to it after the manure has undergone the first stage of fermentation, it will speedily expel from it all the ammonia which it may contain; and thus fit it for sugar-cane cultivation, as before observed.

Sands must be classed as siliceous and calcareous: they are both very important in the effects they produce on various descriptions of land; which of course differ according to the nature of the soil to which they are applied. In stiff clay soils for instance, siliceous sand is of peculiar benefit, in preventing the tendency to coalesce and form a hard coherent mass, and converting it into a brick mould; wherever it be applied in sufficient quantities. On reference to page 47, it will be seen how beneficial sand is in this respect; converting a comparatively barren clay soil into a rich, workable, brick mould. The sand obtained from rivers is of the siliceous kind, whilst that on the sea coast partakes more of the calcareous, as being in a great measure comprised of very minute fragments of various marine shells. I do not consider that planters in general, use sand so freely as they should do; and in recommending a liberal allowance of this manure, I must remind them that sand (of whatever description it may be) once added to the land, not only opens it and constitutes it a fine workable soil, but is always undergoing decomposition or oxidation; whereby silica on the one hand, and lime on the other, are liberated and rendered available to plants as food in their proper forms. Heavy clay lands once properly treated with sand become entirely changed in character; they do not require yearly additions, but are permanently fixed as brick mould soils. The labour may be heavy, but bear in mind that it only requires this once: now compare the permanent advantages gained, with the mere labour of carting, distributing, and ploughing the sand into the soil, and I am sure the advantages will be found far to outweigh the attendant labour and expense; especially if the fields so treated be near "the works," and the sand has not to be carted from extraordinary distances.

Mud obtained from rivers, creeks, ponds, nullahs, tanks, &c. &c. usually abounds in mineral and vegetable constituents of the highest order; and is in supply a cheap, plentiful, and easily procured manure. The fertility that it imparts to soils is very great, and consequently it is highly esteemed by all who have ever used it. It is a very favourite manure with the natives of India and Egypt; and I have known many cases in the former country, where fields have received during a series of years no other description of manure, and yet produced abundant crops. In the West Indies, also, the ponds are on many estates cleaned out annually, especially in the parish of Trelawny in Jamaica: but the practice of placing this mud in the cattle-pens amongst the cattle manure is not advisable, as the metallic oxides contained in the mud fix the ammonia, and convey it to the cane-fields in a form not volatile. I would always recommend its instant cartage to the fields (as it comes from the ponds or elsewhere), and speedy incorporation with the soil, by means of the plough and harrow.

I have understood that in the Mauritius, sea-mud is now obtained from the harbour of St. Louis; and that its application to cane-lands has been attended with the most advantageous results. I can fully imagine this to be the case; and indeed the only cause for apprehension that I can perceive in this instance, is the liability of planters being seduced by the large size and luxuriant growth of canes so treated, into allowing a larger amount of this saline mud than is desirable for the quality of the juice. The prejudicial character of a highly saline soil is particularly pointed out at page 44; and for the same reasons, I would warn planters against the use of sea-mud in quantities sufficiently great to prejudice the quality of their sugar.

Another source of mud is by inundation or irrigation; as when the great rivers of India overflow their banks, and flood the country for miles around ; or when fields are irrigated with water derived from a muddy river or pond. Of the valuable deposit of mud, perhaps the Nile, in Eygpt, affords the best and most familiar instance; but there are numerous rivers in India which in a lesser degree perform the same office to the districts through which they flow. These latter are, however, very uncertain and treacherous in their deposits; at times leaving a layer of rich mud, and again, at other times, overwhelming and throwing out of cultivation whole tracts of country by the immense quantities of sand which they deposit.

Salt and sea water.—Saline substances in moderation are beneficial to a cane-field, but when they abound in too great a degree, the sugar made from the canes is very attractive of moisture and has a great tendency to deliquesce. Great advantages have accrued from the application of salt and even salt water to many soils; but some judgment is necessary in deciding on the soil demanding such assistance, and the quantity which may be used. On low alluvial lands near the sea-coast, there is generally too much saline matter present in the soil; but on the uplands it may at times be found a desirable manure. In England, common salt is much used, and is steadily advancing in favour, being considered an excellent fertilizer. Its use is generally recommended when it is partially or entirely decomposed, by mixing it with twice its weight of lime in the dry state, and allowing the mass to remain undisturbed for a period of two or three months; by this method two salts are produced,—carbonate of soda and muriate of lime.

For oat and wheat crops, in England, from forty to sixty bushels of this mixture are commonly used; but for cane-crops it would be necessary to ascertain with exact precision the quantity that different soils would bear.

Ten bushels of salt mixed with twice its weight of lime, in manner above stated, will, I imagine, be found ample for one acre of cane-land: it must, however, in all cases be applied with caution.

Chalk is a friable carbonate of lime, containing at times small portions of alumina, oxide of iron, and silica; and, as a manure, is very valuable in certain lands: on calcareous soils of course it is altogether unnecessary. Applied to cane-lands, its effects are extremely beneficial, producing a rich saccharine juice in the cane, which always makes strong grained and fair sugar. It is sometimes sent out to West India estates as manure, the ships carrying it out as ballast, and loading home with the rum and sugar crops of those estates; by which arrangement it is supplied very cheaply.

Soot is a powerful manure, but as it contains large quantities of ammoniacal salts,* it cannot be considered eligible for cane-fields.

In England it is often mixed with an equal quantity of common salt, and the mixture applied at the rate of fourteen bushels to the acre for wheat, carrots, parsnips, &c. According to the analysis of Mr. Solly, it contains in one thousand parts: †

Combustible matter	371	parts.
Salts of ammonia	426	,,
Salts of potash and soda	24	,,
Oxide of iron	50	,,
Silica	65	,,
Alumina	31	,,
Sulphate of lime (gypsum)	31	,,
Carbonate of magnesia	2	,,
	1,000	parts.

Soot, and other ammoniacal manures collected on an estate, can be turned to very good account by being applied to the grass pieces; and will not only render the crops of grass abundant, but will give a large return of Indian corn

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* Soot was once extensively used in England for making both sulphate and carbonate of ammonia.

† Johnson's Gar. Almanack, vol. i. page 46.

(maize), if it be planted between the rows of grass, as suggested at page 183.

The foregoing remarks on the different manuring substances contained in the table of manures, will, I hope, serve to inform the planter, not only of the manures proper for cane cultivation, but also of those which he has hitherto been in the habit of using. I have endeavoured to shew, in as simple and familiar a manner as possible, the chemical constituents of each, and the reasons and manner whereby their various influences are exerted; so that the planter can never feel at a loss when dealing with the subject of manuring. Having been so diffuse in my explanations, it only remains for me, in closing this chapter, to remind the planter, *that the very best manure in the world for cane-plants is the cane-plant itself; and if to this be added a liberal atmospheric manuring (ploughing), nothing further will be required to keep up a continual and unimpaired fertility.*

NOTE FOR THE EAST INDIA PLANTER.—I have not mentioned the use of petroleum, or earth oil, which can be had in great abundance from Arracan and Rangoon; because its value is only in relation to the effect it has on the *white-ant.* Any one can easily satisfy himself that land tainted with petroleum is instantly abandoned by those scourges; and I have also found that cane-tops, or cane-cuttings, soaked for a few minutes in even water impregnated by petroleum, were never attacked by them. In short, they (white-ants) seem to have an extreme antipathy to the effluvia of petroleum, and I therefore imagine that it may be successfully used as a preventive; although its most desirable action can only be where the soil itself is impregnated with it. It is quite true that arsenic eaten by white-ants destroys them, and also those who devour their poisoned fellows; but it is a very ineffectual remedy, and can only succeed on a very small scale.

CHAPTER V.

ON IRRIGATION.

The irrigation of cane-fields is a subject of exceeding importance to the sugar-planter; but I am sorry to say that I believe it to be one of which the generality of planters are for the most part ignorant. The apathy which has been manifested in this respect is quite remarkable; especially when we look around us, and witness the many improvements which are daily being introduced into every art and every science: aye, even into the commonest occupations and pursuits of life.

In a tropical country, the subject comes before us in a stronger light than in the temperate and humid climate of England. Hence, many proprietors of sugar estates, who have never been out of the United Kingdom, actually cannot conceive the loss that is sustained by the sugar-cane fields not being irrigated during seasons of dry weather; but if these gentlemen were only to allow their attention to be directed to the operations of their gardeners during the hot summer months, they would see the men busily employed, water-pot in hand, irrigating the various beds of flowers and other plants in their gardens. Now, suppose one of these gentlemen to issue an order, prohibiting the use of the watering-pot in his garden: what would his gardener and other people think of him? Would they not pronounce him to be insane, or something near akin to it? Certainly they would: but why? Is it not because a gardener could not hope to keep up his garden in the flourishing and productive condition it should be, without the aid of his watering-pot? Undoubtedly it is.

Then, if the irrigation of a garden, in temperate, humid, foggy England, be indispensably necessary, how much greater must be the requirement in a tropical climate; where, at times, the sugar-cane plants are almost burnt out of the ground.

In the greater part of Upper India, it is impossible to cultivate even the common native cane without constant irrigation; but in the West Indies, the Straits Settlements, and many other parts, the cane is grown altogether without other watering than that obtained by the rain which falls.

Now, of all the countries that I am acquainted with, Singapore, (situated at the south-eastern extremity of the Straits of Malacca,) is the most seasonable,—*id est*, more frequently visited by fine seasonable showers. These usually occur every fourth or fifth day, so that the soil is kept quite moist and in a condition highly favourable to vegetable life; but even in this favoured spot, I have known a spell of dry weather to occur, which did considerable damage to the sugar-canes on the two estates. Malacca is very similar to Singapore in regard to frequent showers, and in like manner has occasionally periods of hot, dry weather; but Penang and Province Wellesley are much more subject to spells of dry weather, which also are of far greater duration.* But, on the whole, there can be no country more seasonable than these three settlements; nor is there a country where irrigation can be more easily effected. In Province Wellesley, there is not one estate which could not irrigate every field, by merely raising water from a depth of from six to ten feet, in the very driest weather. It is impossible to name a country offering greater facilities for irrigation, and I hope it will not be long ere every estate provides itself with the requisite machines for performing this important and highly beneficial operation. But in the West Indies, long periods of dry weather very frequently occur, when the planters are in despair at the ruin and destruction of their crops: the most dismal forebodings, the most lamentable complaints are heard on all sides; but none seem to attempt a remedy: none turn their thoughts to irrigation, or appear to recognise it as the great and only safeguard against droughts.

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* One simple fact serves to shew the relative vicissitudes of season between Penang, and Singapore and Malacca; this is in the cultivation of the nutmeg tree, which in Pinang cannot be cultivated without considerable irrigation, whilst in Singapore and Malacca such a thing is never required.

Considerable discussion has lately arisen in Jamaica on the subject; but as no steps are taken to justify by experiment the arguments brought forward in favour of irrigation, we can only view them in the light of mere talk. It is with very great reluctance that I so characterize a discussion which I had hoped would have led to really practical results; but, as nothing even experimental has resulted, I am compelled to believe that the full benefits of irrigation have not yet been recognised or acknowledged.

In 1847, his Excellency Sir Charles Grey, Governor of Jamaica, in addressing the Royal Agricultural Society of Jamaica, made the following very sensible and correct remarks:—"Upon the subject of irrigation, as it has recently been so much discussed, I am rather reluctant to enter; especially as it seems to have been thought that extravagant and vain hopes have been held out or entertained. I am not myself at all of that opinion; for I never saw a country in which it appeared to me, that more of what is useful remains to be done with the waters from above and the waters from below. And yet I have seen other and far distant countries, in which there are the ruined and now neglected remains of works accomplished in bygone times for the same purposes (irrigation), so stupendous that I hesitate to describe them." Thus far his Excellency's observations are strictly just, but in the following, he indulges in speculations relative to the Pyramids of Egypt, which certainly are not the least curious and amusing amongst the many which have from time to time been entertained. He says—

"There is reason to believe, indeed, that the greatest structures that the power of man has ever raised, and which belong to the earliest periods of which we have any record, and perhaps to periods of which we have no record at all, were dedicated to agricultural irrigation; and, although I have never yet visited the banks either of the Euphrates or the Nile, I venture to say, upon grounds which I cannot attempt now to disclose, that a more probable use of the Pyramids themselves than any which has yet been assigned to them, is, that from higher points of the Nile, the river waters were conducted, by the subterraneous channels which still exist, into their vast interior, and elevated chambers of the most perfect and curious masonry, for a more regulated and more manageable supply of water to the plains of Memphis than the periodical and purposely excluded inundation could have supplied; and one which might be more profitable to those who should have the command and control of it."

Whilst favouring the society with this altogether new light as to the purposes for which those celebrated structures were originally erected, his Excellency kept the attention of its members palpably fixed on the great subject of irrigation: which indeed was the important point; and the ingenious theory advanced by his Excellency no doubt sent many home to dream of irrigation, who otherwise would not have bestowed a thought on it.

The irrigation of land in Jamaica is one which any friend of the country may well take up; not only from its great advantages to cultivation, but also from the great facilities which in numerous instances exist. Take, for instance, the three estates close to Kingston, viz. Hope, Papine, and Mona: no man will venture to assert that they cannot be irrigated. They draw the supply of water requisite to turn their several mills, and furnish Up-Park-Camp from the river; and in like manner they could obtain a much larger quantity, if care were taken to look more attentively after the bunding of the river.

But, in all parts of Jamaica, estates are to be found with the most admirable facilities for irrigation; yet those facilities are utterly neglected. As one amongst the hundreds possessing extraordinary advantages in this respect, witness "Golden Spring" in St. Andrews: but does the manager or attorney of that estate ever give the subject a moment's serious consideration? I fear not.

So it is all over the island: fine estates, with beautiful streams running through them, or situated on the banks of rivers, are allowed to have their canes burnt out of the ground, and the whole crop risked on the chance of a coming shower; whilst a small portable engine and pump would not only prevent all risk to the canes, but, by affording them an ample supply of water, would keep them in the highest state of vigour and luxuriance, at a time when other canes not so irrigated would be parched and burnt up.

The time has now arrived when the neglect of such advantages can no longer be tolerated: the keen competition which the West India planter has been forced into, renders necessary the appliance of all means; not only those already existing, but also those which art and science can create. In the matter of irrigation, very many estates have the facilities already existing, awaiting only the application of labour to turn them to a proper account; other estates are in a position to create facilities, by digging wells, &c.; whilst, again, there are estates so situated that irrigation would be next to impossible, if not altogether so. In the first case, the methods whereby the water may be conducted and distributed over an estate can be easily arranged, if once the determination be formed to make it available: in the second, the grand question is, as to the depth to which a well would have to be sunk, in order to secure sufficient water for the purpose required.

Now, in a very great number of instances, the depth would be but moderate, consequently the expense would be limited, and the undertaking such as could with great propriety be carried out; but where the depth is extreme and the expense necessarily very great, of course the idea could not be entertained.

With these few remarks on the expediency of irrigation in the West Indies and the Straits Settlements, and the absolute necessity in the East Indies, I will now proceed to a more particular investigation of the subject; trusting that my explanations and suggestions may prove of practical utility to the planter.

We must view the application of water to a cane-field, first, in respect to the manner in which it renders soluble the constituents of the soil, and in that form presents them to the plants growing thereon; secondly, in regard to the oxygen that it contains in solution, which acts on the organic and alkaline constituents of the soil, and converts them into alimentary substances for plants; and, thirdly, in relation to the various other substances which it holds in solution, and consequently supplies to the soil: as potash, silica, &c. &c. In these two latter respects, the waters used in irrigation must be extremely variable, both from the sources from which they are derived, and also from the great difference which the water of one river presents to that of another.

In estimating the value of river water, for instance, reference must be had to the country through which those rivers have passed, as well as the particular formations of the mountains in which they rise.

In India and many other parts, rivers run for several hundreds of miles through countries characterized by many varieties of soil, and consequently their waters are much affected at times.

The Nile is a celebrated instance of the valuable substances which river water at times holds in solution, and deposits over the country it inundates. The rising of this river is owing to the very heavy periodical rains that fall in Abyssinia, from June to September. Hence, in

Egypt, it begins to rise in the former month, and does not commence falling until the end of the latter; during which time a large deposit is bestowed on the lands which are inundated. After the waters have subsided, the ground is found covered with a rich mud, composed chiefly of argillaceous earth and carbonate of lime; which fertilizes the land to that degree, that although it has been cropped continuously for the last 3000 years—often yielding two crops in the year—yet it retains its ancient fertility, and requires the very smallest amount of tillage.

But if we glance at the sources of this remarkable river, and the country through which it takes its course;—if we look back at it as an impetuous torrent, rushing from the mountains' heights, disentangling and in solution carrying to the plains below those mineral particles which together form the essentials to fertility:—if we remember that in its course it flows through upwards of 2000 miles of rich soil, receiving in that course a vast number of tributary streams, each deeply laden with vegetable matter, aluminous and other valuable earths, obtained from the various soils through which they pass,—we cannot be in doubt as to the origin, or surprised at the extent, of the fertilizing principle contained in these waters. But few rivers are so uniform in the character of their deposits as the Nile, and none are so noted for the fertility which they impart. In islands such as those of the West Indies, large rivers cannot be expected to exist; and, indeed, even in Jamaica they may more correctly be termed streams, and often mere mountain torrents. In this case, they have no fertile plains or sandy wastes to pass through; and, consequently, their waters are generally clear and sparkling, except when heavy rains occur to render them turbid by the drainage of the neighbouring country. But in India we have the Ganges and numerous other rivers running vast distances, through countries presenting extremely variable characters; and every year furnishes us with instances of whole tracts of land being entirely overwhelmed by deposits of barren sand, whilst other tracts, again, have been highly fertilized. Of all the rivers that I know in India, the Little Gunduck bears the best reputation for the uniformity and richness of its deposits, whilst all the others in Bengal are capricious and uncertain in the extreme.

But river-water generally contains silica, potash, oxygen, and other substances conducive to fertility, independent of the extraordinary matter contained during heavy rains. It is during the dry season that irrigation is so necessary, and therefore we could only expect to find in the water those substances ordinarily held in solution. Liebig tells us "that the sugar-cane and others of the same tribe thrive luxuriantly, and delight in marshes, in argillaceous soils, in streamlets, and other places, where the change of water constantly renews the supply of dissolved silica." He likewise tells us that the potash abstracted by grass plants is restored to the soil by an annual irrigation, in reference to which he says—"In the vicinity of Liegen (in Nassau), from three to five perfect crops are obtained from one meadow; and this is effected by covering the fields with river-water, which is conducted over the meadow in spring by numerous small canals. This is found to be of such advantage, that supposing a meadow not so treated to yield 1000 lbs. of hay, then from one thus watered, from 4000 to 5000 lbs. are produced." Again, when alluding to the deposit by plants of excrementitious matter in the soil, he shews how the irrigation of fields affects this matter by reason of the oxygen contained by the water in solution:—"In the soils in the neighbourhood of the Rhine and Nile, which contain much potash, and where crops can be obtained in close succession from the same field, the fallowing of the land is superseded by the inundation: the irrigation of meadows effects the same purpose. It is because the waters of rivers and streams contain oxygen in solution that it effects the most complete and rapid putrefaction of the excrements contained in the soil which it penetrates, and in which it is continually renewed. If it was the water alone which produced this effect, marshy meadows should be the most fertile."

He here speaks of the effect it produces on the excrementitious matter alone; but, as we have before seen, oxygen also effects a disintegration of the alkaline constituents of the soil: hence, lands that are irrigated with river water do not require to lie fallow.

Every planter knows that to "lie fallow" means to remain out of cultivation; but as very few are aware how the land regains in this state its power of producing crops, it is necessary that I direct their attention to this point, to show the peculiar value of irrigation.

When a field has been cropped for some time, and the crops have been for the most part (or entirely) removed, the land loses for a time its power of producing; by reason of the alkaline constituents necessary to the growth of the plant being exhausted, and also from the pernicious influence exercised by the accumulation of excrement deposited by the plant itself. The field is then abandoned for two, three, or four years, and allowed to lie fallow during that time, in order to recover itself, as it is generally termed.

Now I have known lands lying fallow in this way, quite close to the mill-yard, without once having a ploughing bestowed upon them, until they have been required again for planting; so that, during a period of four or five years, these lands, which could easily have been placed in a position to bear crops, have been allowed to lie fallow, whilst other lands at a great distance from the works have been cultivated, to the great increase of labour and heavy cartage of canes.

To effect the object desired, it was only necessary to assist the land to a proper and uninterrupted supply of oxygen; which might be done by facilitating the free admission and circulation of air into the soil, by frequent ploughings and consequent pulverization. But if the air produces this effect, irrigation produces it also, and in a much more powerful degree, by the oxygen which it holds in solution; independent of the silicate of potash and other matters* which it affords to the soil. Of these matters, river water very frequently contains large quantities; all which, by irrigation, are supplied to lands with the same effect as that produced by inundations: only with this material difference, that in irrigation we can choose our time, season, place, and description of water; regulating the quantity, and apportioning it to the different fields in succession as we may judge desirable, and this too during all stages of the cane's growth. On the other hand, the inundation comes, perhaps, when and where it is not required; sometimes depositing rich mud, at other times mere sand, and not unfrequently remaining so long on the ground as to rot the canes and thereby destroy the hopes of the crop entirely. In short, we have in irrigation all the beneficial effects of an inundation without its evils: a certain, well-regulated result, instead of a risk, uncontrolled and pregnant with anxiety.

Under the system of irrigation and ploughing, therefore, land never requires to lie fallow (from the causes before noticed); but its being pursued in conjunction with the methods of manuring I have recommended, renders a constant succession of the same description of crops perfectly attainable. Let us now glance at it in another light: viz. as affording the means whereby the constituents of the soil are supplied to the roots of plants in the only form that they can furnish nourishment; that is, in solution.

We find that roots can only receive food from the soil by the aid of water, which, falling on the land as rain, or being conducted over it, as in irrigation, renders soluble the various substances required by plants for their growth and development.

From this we perceive that although a soil may contain all the other elements which conduce to the highest fertility, yet, unless supplied with water, plants cannot grow on it, because their roots cannot appropriate the rich stores which are present, except through the medium of water; and it follows that during seasons of long-continued dry weather, when the soil is parched up, plants cannot extract from it the sustenance they require, from the simple fact of water being absent; so that they either become stinted in their growth, or are altogether killed.

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* The waters that flow within or upon the surface of the earth contain various earthy, saline, metallic, vegetable, or animal particles, according to the substances over or through which they pass. Rain and snow waters are much purer than these; although they also contain whatever floats in the air, or has been exhaled along with the watery vapours.—*Ure.*

How many planters find their estimates of crop entirely disarranged by the occurrence of a drought, and find cane-piece after cane-piece falling short of the quantity of sugar it has been rated at. Truly can such persons bear witness to the anxious and melancholy feeling with which they have viewed this distressing loss, continuing during perhaps some months; and with what joy they would have hailed the appearance of a well-charged cloud. Now, in cases of this kind, irrigation affords an effectual safeguard against injury; and even keeps up the vegetation of the plant to the highest possible degree that artificial means can accomplish. The ploughings and waterings succeed each other, and the vigorous growth and perfect development of the canes proceed uninterrupted, whilst all else around is parched and burnt up. In irrigating during hot dry weather, there is another feature which most *materially* influences the plant; this is the hot vapour which a hot sun causes to rise from irrigated lands. This vapour, as it rises from the ground, of course passes up through the foliage of the canes, in order to escape into the air; but in its passage it is powerfully attracted by the leaves and other green parts of the plants, and its moisture is made use of. When the air is exceedingly dry from long-continued dry and hot weather, the creation of this moist atmosphere around and amongst the growing canes must be highly beneficial; as the external organs of assimilation are thereby supplied with the means of exercising a more vigorous action, to the refreshment and corresponding improvement of the whole plant. Hence, it is apparent that irrigation benefits the plants both by the food which it supplies to their roots, and the nourishment that it affords to their leaves and other green parts.

The countries where irrigation is practised as a matter of course, are India, Egypt, Arabia, Persia, and China.

On the banks of the Nile, I saw innumerable irrigating machines in full operation: they mostly consisted of an endless band, with a number of wide-mouthed earthen pots tied on it at distances; which band worked over a drum wheel that had spikes or teeth, fitting into holes in the band, so as to catch and carry it round; the drum wheel shaft being moved by a large cog-wheel fitted on a vertical shaft, which was worked by animals of various descriptions, as camels, horses, mules, oxen, and asses.

On the banks of the Euphrates, the same scenes may be witnessed, and the same kinds of machines also; but the Persian wheel is used likewise. In China, bamboo wheels, endless bands, and what is termed the Chinese pump, are in constant use in the dry season.

But of irrigation, as pursued in India, I can more correctly speak; as I have had considerable experience in the several methods. It will not be necessary, however, to mention all these; I shall, therefore, confine myself to the three most common methods. The first is, that by means of an upright pole placed in the ground, the upper extremity of which has two prongs, between which another pole is fixed by means of a pin, that fits in either prong and forms the axis on which the cross pole works. At the short (and heavy) end of this cross pole, a large stone or clump of earth is tied, sufficiently heavy to raise the earthen pot or leathern bucket, which is attached by a rope to the other end of the pole. The native stands on a board over the well, and pulls by the rope until the bucket reaches the bottom of the well and fills: in doing which, the one extremity of the pole is brought down to the level of the man's head, and the other, with the weight, is proportionably elevated.

The bucket being full, he then allows it to ascend; but controls the motion by letting the rope slip through his hands, until the bucket is sufficiently high to allow of the water contained in it being discharged into the appropriate gutter.

As the water runs into the field to be irrigated, another man there stationed receives it, making little channels to guide it in different directions; and with a light wooden shovel he very dexterously scatters it over the land as far as he can throw it, moving on from time to time, in order to bring a fresh circle within his range; and so he continues until the man at the well calls for relief, when they change places.

This is a common mode of irrigation throughout India, and is usually applied to wells and ponds; from which it may be inferred that the depth of wells is not great. This indeed is the fact: throughout the whole Delta of India, I believe the average depth of wells may safely be stated at from twenty to twenty-five feet; often much less. The lift from rivers is generally much more (during the height of the dry season); averaging, I should think, about thirty-five feet: which, however, is not by any means a great height for a force pump.

The second method of raising water which I shall describe, is that performed by the aid of baskets. In this case, the water of ponds is usually availed of, as they afford facilities which wells and rivers do not. The basket used is round, closely woven and very shallow: or rather very slightly concave; to it are attached four strings, two on the one side and two on the other, about four or five feet long. Steps are cut in the bank about six or seven feet above each other, with little channels running from the top of one to the foot of the other; and two natives take up their positions at each of the steps, and bale up the water with their baskets. For instance, about two and a half feet above the level of the pond, places are cut for the two men to stand, having the water between them; they then take the basket by the strings (each man having one in either hand), and giving it a swinging motion, just skim the top of the water, filling the basket and jerking its contents cleverly on the top of the first elevation or step. Here it is received in a kind of bed, with raised edges to confine the water, and dry grass laid at the bottom to prevent loss by splashing. From this it runs along to the foot of the next step or elevation, from whence it is raised as in the former case; and so on to the next elevation, until it reaches the general surface of the land: so that by this method six men are required to effect the elevation of each basketful of water to the surface of the land; which we may reckon at from eighteen to twenty-one feet above the level of the pond.

The quantity of water which these men will raise in a day is, however, very remarkable, considering the means used: but it is only the surprising dexterity which they attain that enables them to perform what they do in this way; although they also display great powers of endurance.

The next mode that is very generally adopted, is that by the moat* and a pair of bullocks. In this instance, there is erected over the well a rude but strong framework, with a wooden shaft running across, which has on it a small revolving drum wheel. Into this the rope is dropped, and the cattle being attached, the moat is let down into the well and filled with water: the cattle then run down an inclined plane, of just the same length as the depth of the well, and draw up the moat; which is immediately emptied by the man stationed on the well for that purpose: the cattle continue thus running down the plane and walking up again until they are relieved.

To work the moat all day requires four bullocks, three men and one boy; who will, according to native calculation, irrigate one-third of a pucka beegah in that time, at the following expense (in the Goruckpore, Ghazeepore, and other districts) :—

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* The moat is made by having four or six wooden ribs or hoops, over which a bullock's hide is drawn; it has also a rim and handle, made of a common creeper, cut in the jungle. It usually holds about twelve gallons.

Contract work.	Annas.		Pence.
2 pair of bullocks, at 2 annas a pair	4	=	6
3 men, at 1½ anna	4½	=	6¾
1 boy, at 1 anna	1	=	1½
Total annas	9½	=	14¼ Pence.

One pair of bullocks work from daylight to half-past eleven o'clock, A.M., and the other pair from half-past one to half-past five o'clock P.M.; irrigating one pucka beegah (two-thirds of an English acre) in three days.

Of the three men mentioned, one attends to the discharging of the contents of the moat, another makes little channels to conduct the water over the field, and occasionally assists the third man, who is employed in scattering the water about. I have before stated that this last operation is performed with small light wooden shovels, in the handling of which the natives are very dexterous.

The natives reckon one good pucka well to be equal to the supply of water for thirty pucka beegahs of land during the year; and such well costs, in the Goruckpore district, about one hundred rupees.

The size of this well would not allow of more than three moats being worked at once, so that it could only irrigate one beegah a day; thus occupying thirty days in giving each beegah a watering. In the height of the hot winds, this interval of thirty days between each watering would be found too long; so that the natives, estimating thirty beegahs to each well, must reckon on at least fifteen nights work.

I have never timed these native irrigators, but I have very frequently calculated that a smart set of bullocks and driver may make one trip a minute, delivering twelve gallons of water; which would amount to a distance travelled in the day of about seven and a quarter miles, and of water raised about 7,200 gallons. This, together with its distribution over the field, would only cost about 1*s.* 2¼*d.* making for the irrigation of an acre, according to this plan, the sum of 5*s.* 4*d.* This appears a very small sum, when we consider the number of men, boys, and cattle it takes to perform that amount of work: but that is a very erroneous mode of calculation; for the question with the planter really is, whether by any other method he can give his land as good a watering at a cheaper rate. That he can do so I can abundantly prove; and to accomplish it I have no occasion to call in the assistance of any imported motive power; for India has in the fierce hot winds a power of the most valuable nature.

If the hot winds parch and burn up everything in the shape of field produce, they at least afford, at the same time, a power whereby we may carry on irrigation to any extent. It would be difficult, if not impossible, to point out another country where the winds are so peculiarly favourable for irrigation as in India: but to observe this more clearly, we must bear in mind the months that it is particularly required in. These, then, as I have before said, are March, April, May, and part of June; during which time the whole country is parched up: but it is also during these very same months that the west winds blow so strongly.

I have myself known the west wind (the hot wind), blow every day for upwards of a month incessantly; and that, too, so powerfully as to be capable of turning any description of windmill. The hot months are indeed entirely ruled by two winds alone, the west wind and the east wind; if the one does not blow, the other is sure to take its place, so that they divide the period between them: but the west wind greatly predominates.

Now, with such a great motive power at command, the planter of Upper India should have on his estate the most perfect system of irrigation possible. He should have a small windmill for every well on his property, besides having several on the banks of the different ponds, nullahs, and rivers: should there be any. These might be of two, four, and even six horse-power each, to suit the different wells, ponds, and rivers on the property; and might be either moveable or stationary: at all events capable of being removed to the factory and housed before the rains could injure them.

Many wells run dry when a little pressed (in India); therefore it is that I have made mention of so small a power as a two-horse windmill: but if the wells are dug to a proper depth, there is little fear of their being run dry by so small a motive power. Yet, with a moderately good pump attached to it, this power would be sufficient to raise at least 120 gallons a minute; or as much as ten moats, with twenty bullocks, ten men, and ten boys, could together accomplish: with this additional advantage, that it need not be stopped in the middle of the day for two hours, but would pump during that time about 14,400 gallons of water.

Next to having proper means of raising water, the important point is to have a regular and well-devised plan for conveying the water once raised to the different fields destined to be irrigated. This takes us back to the old subject of laying out an estate in the first instance, in a methodical and properly-arranged manner; by means of which alone, power, labour, expense, trouble, and time can be economised.

Where an estate is properly laid out, the various roads situated at regular distances would also form the tracks or lines along which the water-courses would run; each cross road having its watercourse, into which the water supplied at given points could be directed as might be necessary. But when I say watercourses, I do not mean the open mud-channels which answer perhaps more properly to that name in India; but a well-contrived and durable water-way, which I will endeavour to describe before proceeding further.

I must, however, premise, that, although the estate itself be not altogether in one run (as few, if any, in India are), yet that at least it be so arranged that the several parts or patches may comprise from thirty to fifty acres each; in order that a good, properly sunk well may be allotted to each patch, in case no river or jheel be at hand. Where the land can be so obtained, care should be taken that it be in a square or other desirable form, so that the well may be made in the centre. This being attained, the next point is so to conduct the water pumped up from the well, that little or none of it be lost during its transmission from one point to another. This object may be gained by laying down common drain pipes (of whatever diameter may be found necessary), which may be in four regular lines of about 260 feet apart. By this method, thirty acres of land may be permanently laid down at a very trifling expense, as not more than 5,500 pieces of piping would be necessary; and every one acquainted with the upper part of India knows how very cheaply these may be obtained. Each pipe would require to be one foot three inches long, with a large and small end: that is, one end having a shoulder, and being large enough to receive the end of the other pipe, to the extent of three inches; so that in laying them down a little mortar is placed at the joint, and they are fitted closely together. At intervals of from forty to fifty feet along the line of piping, a good-sized naud (a kind of pipkin) is sunk in the ground; so that the ends of the pipes fit into it about two or three inches below the rim (exactly opposite each other), and by the application of a little mortar are made water tight. These nauds then serve as receptacles for the water; from which it may be distributed over the field, either by tossing it out with the wooden shovels in common use by the natives), or by placing the suction pipe of a small irrigating machine into the naud, and so pumping a jet of water over the land as far as the power of the machine can carry it.* The next use of the nauds is their serving as points from which the water can be drawn into any branch piping or mud channels in the fields; and also they are of much utility in detaining the mud, sand, or other matter, which might otherwise lodge in the piping and obstruct the free course of the water.

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* The most useful machine of this kind that I have ever seen is a small fire-engine, drainer, and irrigator, invented by Mr. Baddeley; which is represented and described in the succeeding chapter.

The clay of which these pipes are to be manufactured, would of course be of the same kind as that whereof the common round tiles (for roofing) are made; and, as I said before, the natives can supply them very cheaply: but, to attain a greater degree of nicety in their form and fitting, and to increase the quantity, as well as decrease the price, the employment of a small and compact, pipe-and-tile-making-machine would be very desirable. For 15*l.* or 20*l.* a very excellent one can be procured in England, which, with but few attendants, would turn out 5,000 perfect pipes of the size required in a day; and one hour's teaching would suffice to show the native labourer how to use it. By the use of such a machine, a planter would be enabled to get any amount of pipes for his water ways, besides tiles, for whatever purpose he may require them.

The present system of making mud channels is wasteful in the extreme; whereas, by employing tiles, the supply of water may be carried any distance without other than a most trifling loss, and at an expense quite insignificant.

If wells are sunk to a depth of from twenty-five to thirty feet, and are properly constructed, each one should be capable of affording full employment to a pump worked by a windmill or steam-engine of two horse-power; and every well might have its own little windmill of about that power, which should work the most simple and economical pump a planter can procure. With a lift not exceeding thirty feet, an exceeding simple kind of pump may very advantageously be used.

Plate IV. represents a windmill attached to that simple and much neglected kind of pump, which acts by centrifugal force; causing the water to fly from the centre of rotation, (through arms having openings at their extreme and curved ends) thus tending to form a vacuum, towards which the water in the well is forced by the pressure of the atmosphere; it can, therefore, only act where the column of water is less than thirty-three feet high.

The circle described by the curved arms is sixty-six inches all over, equal to 16·96 feet circumference moved through in one revolution; the pipes and apertures are three inches diameter, = 7·068 inches area, and each revolution of the machine is equivalent to delivering about five gallons of water from the two arms, which at fifty-five revolutions a minute, would equal 265 gallons of water delivered.* This quantity, raised twenty-five feet high, and, divided by 33,000, gives 66,000 lbs. lifted one foot high per minute, or two horse-power; and at a moderate calculation, a wind at the velocity of twenty miles an hour would effect this service with the amount of sail provided. A simple valve is placed at the bottom of the upright tubular shaft, which revolves with the arms, and retains the water when the pump is at rest, in readiness to perform its functions when the wind arises: and it is necessary to fill this shaft and the arms previous to putting it to work in the first instance.

The windmill itself is made on the most approved principle, and its sails are self-acting, to prevent accidents. The engraving is taken from a design executed at my particular request by Messrs. J. Woods and Co., civil engineers, Bucklersbury; and is intended expressly to suit the requirements of the East India planter, although it is alike applicable wherever the winds are sufficiently favourable.

There are many other forms in which windmills could be advantageously made use of: as, for instance, that of Vallance's Horizontal Windmill, or Biddle's Patent Eolian Engine, which is also horizontal; and as the upper districts of India have a very great power in the winds prevailing during the hot months, so no doubt the planters will see the positive necessity of using some of these various descriptions of windmill: but I have considered it preferable to repre-

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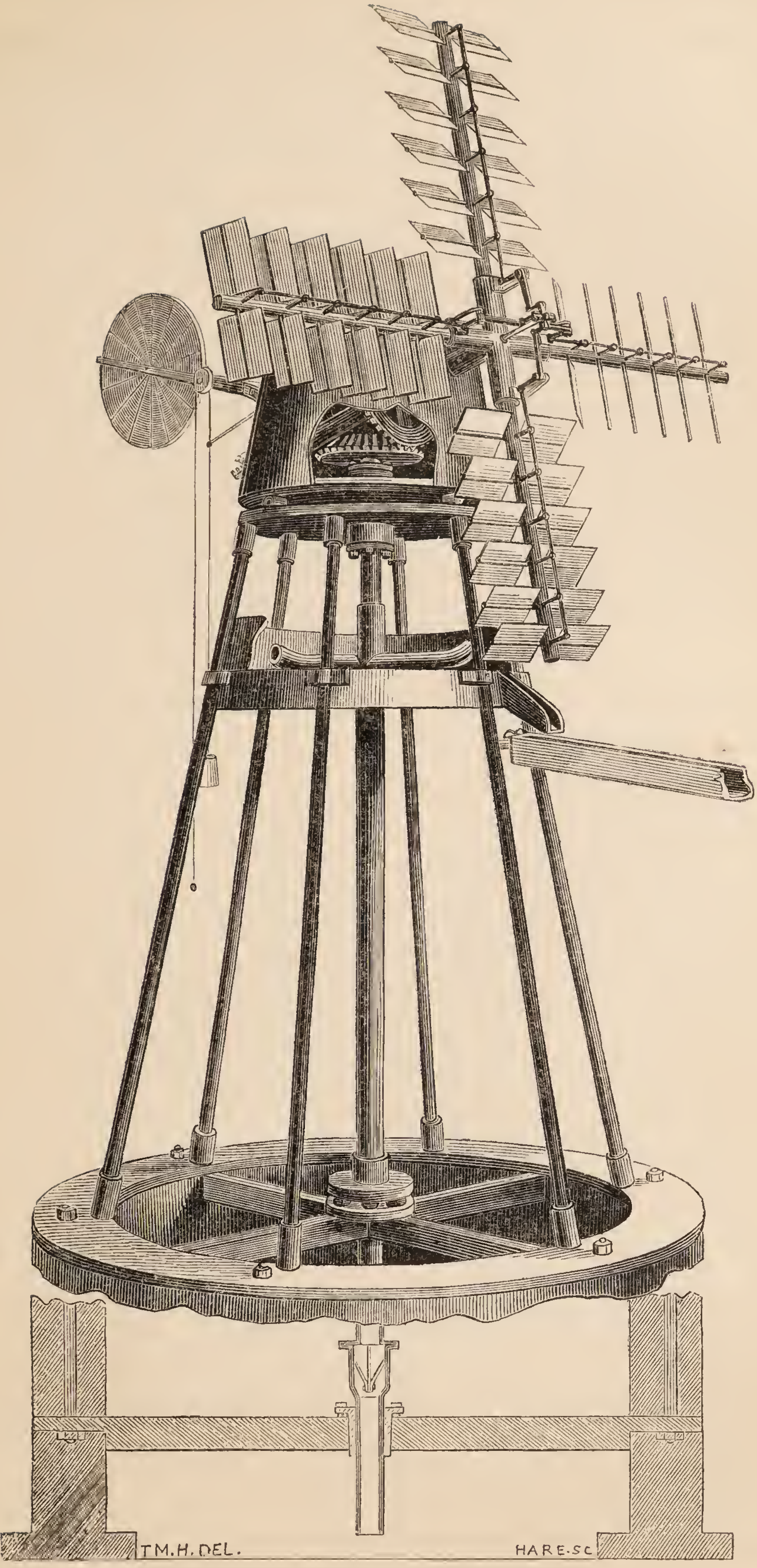
* At this rate, it would raise, twenty-five feet high, 318,000 gallons in ten hours;—equal to the irrigation of seven acres of land, allowing *one* inch water to the foot.



VERTICAL WINDMILL AND CENTRIFUGAL PUMP.

sent the vertical mill, as it will in all probability be better understood by the natives who are placed to work it.

There are, however, many parts of India where the hot winds do not blow: for instance, from Monghyr down to Calcutta;* and although other winds are common, yet, not being of that steady and powerful character, the planters could not depend on them for irrigation. Hence they are either obliged to call in the aid of steam, or put up with the inconveniences of the native systems. In the district of Tirhoot, I rather think that the winds are unsteady, and not to be depended on during the season when irrigation is most required; from which cause no doubt it is that "the Tirhoot Association" has had recourse to steam-power: certain it is that Messrs. J. Woods and Co. have supplied that company with several portable engines and pumps for the purposes of irrigation.

In the Straits settlements, the West Indies, and many other places, the power derived from the wind could not always be calculated on, consequently it is necessary to advise the employment of steam; and it interests the planter to know that description of engine which is most likely to suit his wants. It is with much satisfaction that I am enabled to introduce to notice the portable steam-engine of Mr. W. Cambridge, which is in such high repute amongst our English agriculturists.

At the meeting of the Royal Agricultural Society in 1847, at Northampton, the judges awarded the society's prize of *fifty* pounds to this engine, although there were six others in the field. But the unsuccessful competitors protesting against the decision, it was referred to the council of the Society, who, at the next meeting held in London, "unanimously confirmed the decision of the judges at Northampton awarding the Society's prize of fifty pounds for the best steam-engine applicable to thrashing and other agricultural purposes, to Mr. William Cambridge, of Market Lavington, Wiltshire." The possessor of the actual engine which gained the prize, and other members of the council present, bore ample testimony from their own experience "to the high practical value of Mr. Cambridge's engines in reference to their safety and efficient working, — to their economy of fuel, and their constant freedom from derangement, or the undue wear and tear of their material."

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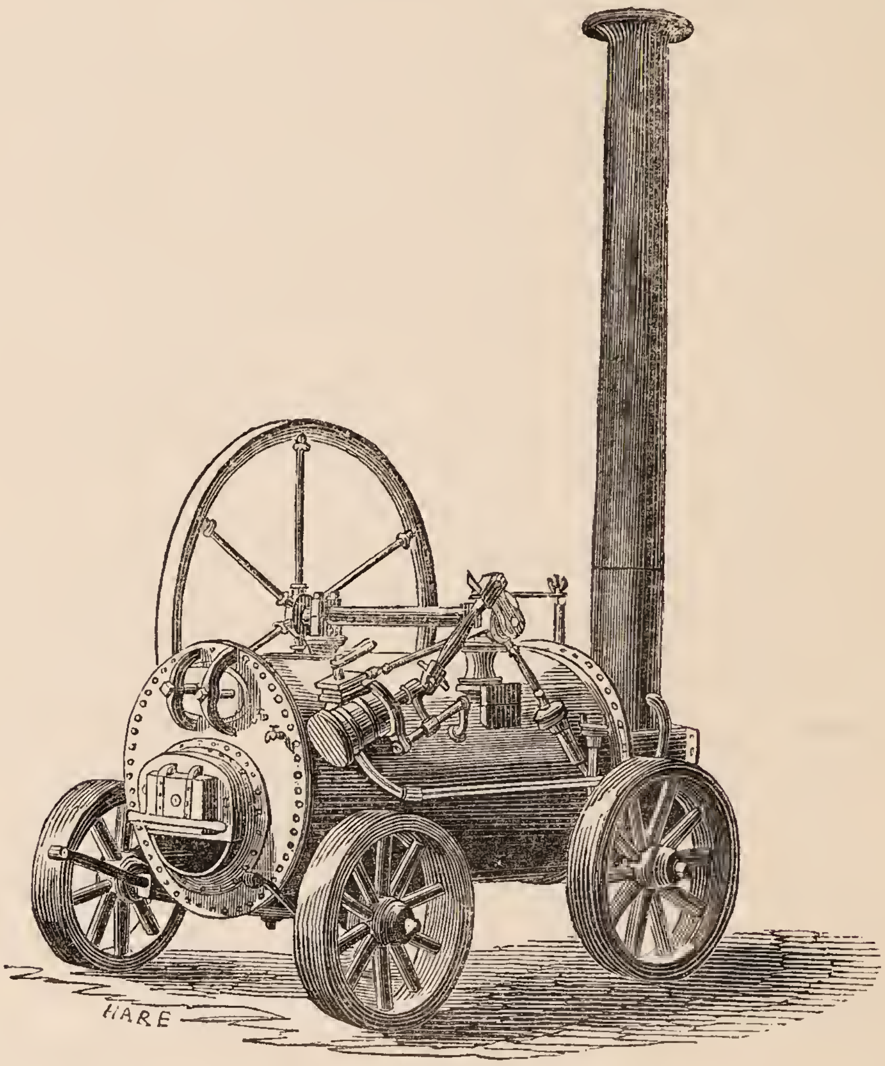
* About Monghyr, Rajmahal, &c., there is what is termed the double wind, which is only the east and west winds, which blow alternately.



Cambridge's Portable Steam-Engine.

This engraving represents a four-horse portable steam-engine, with a boiler eight feet long and nine feet two inches outward circumference, constructed on the Cornish principle. The fire-tube is oval, two feet wide and eighteen inches high: this place forms the fire-place and the ash-pit. The water is heated in a cistern at the end of the boiler by the heated air, which, going from the furnace into the smoke-flue, passes through this cistern and heats the water to about 150° before it is forced into the boiler.

In full work, it consumes about four hundred weight of coals, and about 120 gallons of water in ten hours; and is constantly used by agriculturists in driving a six-horse thrashing machine.

The testimonials I have received from various quarters, lead me to consider it a very valuable description of engine for the planter; and, as such, I present it to him without being in any way acquainted with the person who makes them. The price of an engine such as represented, of four-horse power, is 140*l*., of five-horse power, 175*l*., and of six-horse power, 200*l*.—with governors, 20*l*. extra.

Being mounted on wheels, they can be taken to any part of an estate, and again removed when required; but not being fitted as a locomotive, they could not perform the varied duties of which the latter are capable, and would be called on to accomplish (see page 117).

I have mentioned Mr. Cambridge's engine as one cheap and excellently suited to the wants of the planter in every case, where an actual locomotive is not capable of being worked; but wherever a locomotive can be used in the various operations mentioned at page 117, it would be in every sense better to obtain one somewhat similar to that represented in Plate II.

I have already said so much of the utility of such an assistant on an estate that little more need be added: however, it may be of advantage to remember that an actual locomotive, though it will cost a few pounds more, will, on the other hand, be applicable to a variety of purposes beyond the compass of such mere portable machines as the engine of Cambridge. I am very solicitous that the planter should see this locomotive in its true light, and not be biassed by antiquated prejudices in regard to its use: and, moreover, I am desirous that it should be known that no native of India, Negro or Chinaman, will long be a stranger to its working details. I have always found that these several labourers fell right readily into a habit of working any description of implement or machine that was put into their hands; and, in proof of this, it is only necessary to adduce the different steam-engines worked by common labourers both in the western and eastern hemispheres. Who has ever heard of an accident occurring to one of these engines so attended? We read and hear of frightful accidents happening with steam-engines in various parts of the world; but, in all my experience, I have never known or heard of one occurring where the Negro, native of India, or Chinaman, had the management of an engine.

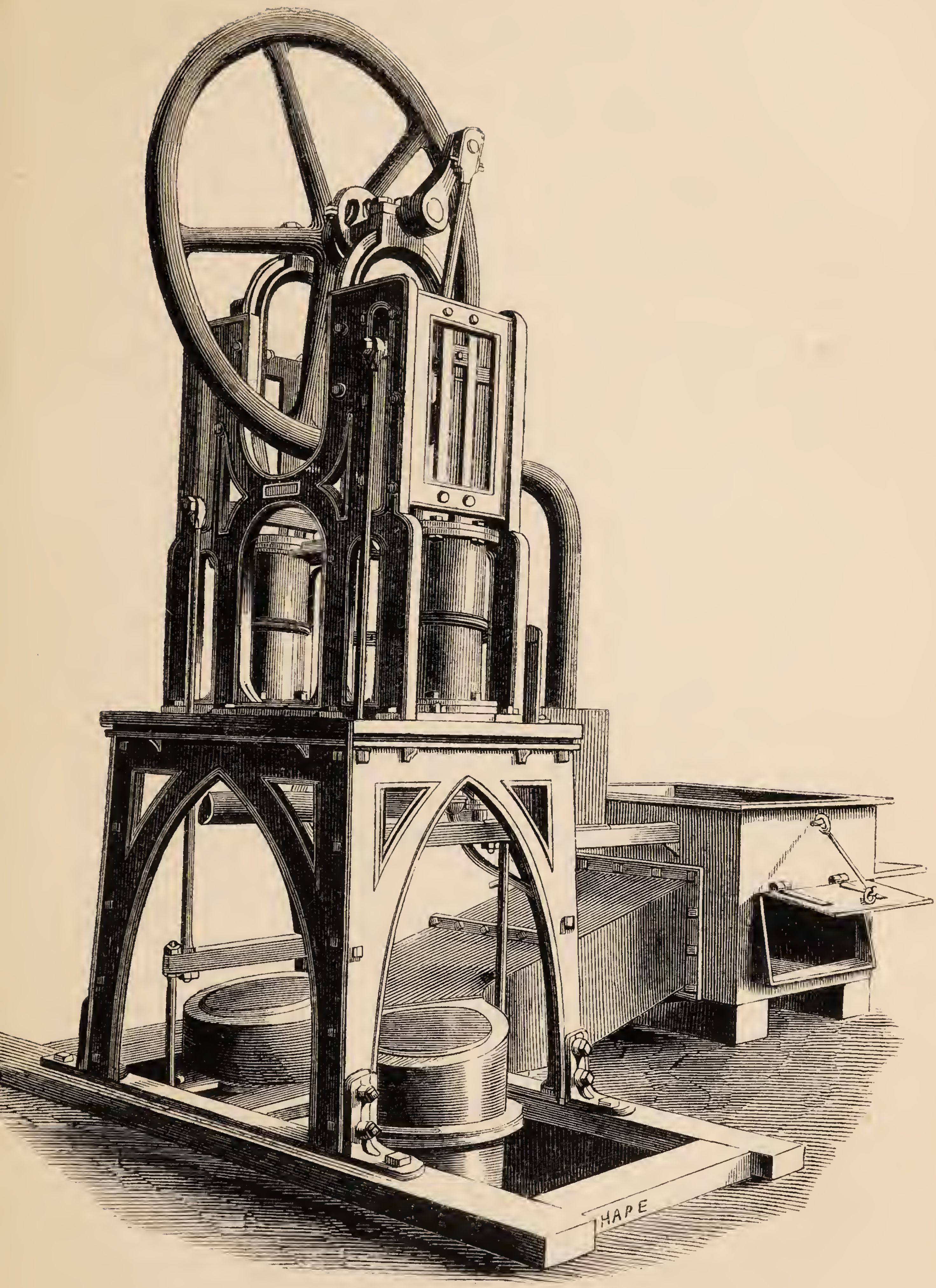
The description of pump to be used, differs very much according to the supply available, and the depth from which it has to be taken. I have already mentioned the centrifugal pump as being perhaps the most simple and most economical to be obtained; but it would be unpardonable were I to omit noticing the extraordinary machine known under the names of "Walker's Hydraulic Engine" and "Walker's Patent Elevator." (Plate V.)

Some years ago, in treating on the same subject as at present, I expressed some doubt of its powers being correctly stated: and, indeed, from a small defect in the valve, these doubts were very generally entertained; but after improvements and more recent experiments have served to establish the remarkable power and efficiency of these "patent elevators."

As I am aware that very great curiosity exists in India relative to the efficiency of these machines, I am happy in being able to afford some information regarding them, which rests on high authority.

As their action is so different from all other hydraulic machines, the ordinary mode of computing their power is in no way applicable; hence such surprise at the actual performances. An authority was given by Government to try Mr. Walker's Hydraulic Engine at Woolwich dockyard; where the large caisson was formerly emptied by a pair of excellent ten-inch pumps, fitted up by the firm of Sir John Rennie. With these pumps it took thirty men (working in gangs of fifteen, and relieving every fifteen minutes) three hours and a half to empty the caisson. With one of Mr. Walker's engines, fourteen men (working in gangs of seven, and relieving every fifteen minutes) emptied the caisson in one hour and a quarter; and have, on recent occasions, done

PLATE V.



WALKER'S HYDRAULIC ENGINE AND PATENT ELEVATOR.

it in less time, without being fatigued. This experiment took place in the presence of Sir Francis Collier, C.B., K.C.H., and Captain Denison, of the Royal Engineers; and Sir Francis, in forwarding Captain Denison's report to the Honourable Sidney Herbert, says:—"I beg to add, that, having seen the pumps in operation, I consider it (Mr. Walker's) to be very superior to Mr. Rennie's, having discharged an equal quantity of water with half the number of men, in half the time."

The great superiority of these machines over ordinary pumps was so completely established with Government, that Mr. Walker was called on to furnish one for the dockyard at Malta, and another for Portsmouth. The Board of Admiralty have likewise determined on applying this invention to ships of war of the largest class; as it is believed that in cases of danger they may be kept afloat by its means, when all other descriptions of hydraulic machines would fail.

Mr. Walker has also erected engines for the Parliamentary Commissioners, for draining in Somersetshire, Norfolk, and Lincolnshire. In proof of its utility in draining land, the estate of Mr. Boult, Runham, Norfolk, affords an instance: a crop of the finest corn was grown there in 1847 on a large tract of land which had previously been uncultivated, from the impossibility of draining it by the other means employed.

These are facts which the planter may rely on; and, although I have never seen Mr. Walker, I have thought it desirable to obtain from him (through the medium of an acquaintance) a table showing the performances of his machine, worked under various circumstances: this has been politely furnished me.

Horse-power.	Gallons Raised at Different Elevations.					
	6 ft. high	10 ft. do.	20 ft. do.	25 ft. do.	30 ft. do.	
2	1600	1250	900	725	550	Gallons per Minute.
4	3200	2500	1800	1450	1100	
6	4800	3550	2700	2215	1650	
8	6400	5000	3600	2900	2200	
10	8000	6250	4500	3750	2750	

Mr. Walker has also adapted a steam-engine to work his elevator: whether the former be his own invention or not, I cannot positively state; although I believe it to be. Two of these engines and elevators, which were constructed purposely for draining estates in the West Indies, were recently erected and tested at Mr. Walker's premises in the City-road; where, with steam at thirty-five pounds upon the inch, and making seventy revolutions per minute,—the piston stroke being two feet—they lifted 6,000 gallons of water eight feet high per minute.

These are certainly very astonishing performances, and in the absence of such excellent authority as that I have adduced, might become a subject of doubt; but the undeniable testimony furnished by so many successful experiments, together with the fact that this invention has had to oppose, solely by its own merits, an unusual degree of opposition and professional hostility — and in the instances mentioned, as well as in many others, it has overcome strong prejudices by the plain fact of its actual performance—renders Mr. Walker's hydraulic machine entitled to the sugar-planter's very attentive consideration.

There are many descriptions of the common pump that are deserving of the planter's notice: the best of them are capable of raising twenty-five feet high, with a two horse-power engine, about 200 to 240 gallons of water per minute. It must always be borne in mind, that a good hydraulic machine (whether Walker's or any other) is not only useful in irrigating lands, but can also be applied to draining purposes whenever required.

It is very difficult to recommend any particular description of common pump: the various claimants are so numerous and their several merits so contested, that I can only advise the planter to deal with some respectable manufacturer direct; explaining to him the requirements of the case; and the chances are that by so doing he is saved a deal of money and trouble in the long run.

In many parts of Upper India the Persian wheel is much used; but I have never seen them so light as they are capable of being made; nor have I seen other than the most clumsy workmanship bestowed on them: this, although it may appear to be a first saving, is nevertheless an enduring and increasing loss. Where Persian wheels are desired, it were far better that they are made similar to the Egyptian band wheel (if it may be so termed). This is merely an endless band, made of rope, grass, &c., passing over the two drum wheels (one in the water, and the other a few feet above the surface of the ground): it has, at intervals, small holes for the spikes of the drum to drop into, so as to draw round the band; and leathern or earthenware buckets to contain the water. By this simple arrangement, the heavy wheel is dispensed with, and the motive power is applied to raise the water alone, and overcome the friction.

"The Chinese Chain Pump" is also much used: but it has always appeared to me that the friction is enormous in comparison to the work performed; I cannot say, therefore, that it is by any means a favourite method of mine. "The hydraulic belt" is also a contrivance pledged to perform great things in the way of lifting water; but the extreme velocity with which it requires to be worked, seems to me an insuperable objection to its adoption.

In fact, there is an endless variety of hydraulic machines of every conceivable form and character; from amidst which I have selected those most likely to suit the planter's purposes. These, then, are first, "the centrifugal pump," represented to be worked by a windmill; second, "Walker's patent elevator," to be worked by steam or wind; and, third, the better description of common pump, to be worked, also, either by steam or wind.

The space that I have devoted to the subject of irrigation may appear very great to those who scarcely know what is meant by the term; but to the East India planter it is a subject of vital importance: one which he will anxiously study, and the successful pursuance of which can alone render his operations of a promising character.

In a country like India, where for many months in the year rain does not fall and everything is consequently parched up, it may be anticipated that great want would exist were not wells dug in very great abundance. Such is indeed the fact, and I am sorry to say that justice is seldom done to the native character in this respect; which makes me the more anxious to express my opinion on the matter.

It is a particular belief of the natives that they propitiate the Deity by providing a grove of trees, and a well of drinking water, where nothing of the kind was before existing; hence we see throughout India, innumerable wells, tanks, and topes (groves of trees) set apart for the behoof of all comers. This practice seems very commonplace to those who reside in Europe, or even in the West Indies; but in India it assumes quite another character: for miles and miles, nothing may perhaps meet the eye but one dead monotonous plain, parched and burnt up; the traveller, suffocated by dust and oppressed by heat, reaches one of these topes, and straightway going to the well, washes his mouth, quenches his thirst, bathes his wearied limbs, and throws himself in the grateful shade to rest: he sleeps,—perhaps makes it his abode the whole night; but whether he rests an hour, or whether he remains for days, he does not leave the spot without invoking a blessing on the benevolent person who established such a welcome place of refreshment and convenience for the poor traveller. There are those in India who are silly and, I may say, wicked enough, to designate all such works of charity and benevolence as being *nam ke wastè* (for a name); but the natives may depend that their benevolent motives, so far from being overlooked, are carefully noted by every sensible, right-minded European who dwells amongst or visits them.

That very excellent officer, Colonel Sleeman, took considerable pains to show the enormous—ay, vast—sums expended by the natives in this way; and, in corroboration of his statements, I can say that the sums they expend in digging wells and tanks, keeping them in repair, and planting topes of trees, so as to furnish accommodation and refreshment to the poor, are quite incredible. But, whilst we speak of them as mere places of refreshment and accommodation for travellers, we must be careful to view them likewise in relation to the present subject—irrigation. The tanks and wells which are so dug and appropriated, are in reality choice benefits conferred on the native cultivators residing in the neighbourhood; who are thereby enabled to irrigate their cane and other crops, and consequently preserve them through seasons of the greatest severity. By this means they are enabled to plant when they otherwise could not, and also to save many a crop, which would otherwise be lost; or so to increase the produce of their fields as to render them doubly valuable. I must therefore express my sincere respect for those natives, who take from their substance large sums to bestow on such charitable, such benevolent works; and I trust that every European planter will endeavour by all means in his power to foster such excellent feelings, instead of striving to disparage the very worthy motives by which they are undoubtedly actuated.

In concluding the subject of irrigation, I must once more urge on the planter the extreme importance of the subject. I must once more remind him that by irrigating his fields frequently and liberally, he not only fertilizes the soil, but also places those stores of nourishment contained in it, (in solution) in the best possible (and indeed only) condition in which the roots of the cane plants can make use of them as food. I beg of him to give irrigation his most serious attention: let no difficulties frighten him from pursuing it, wherever it is practicable; and I can assure him he will never have cause to repent the day he gave his mind to this subject.

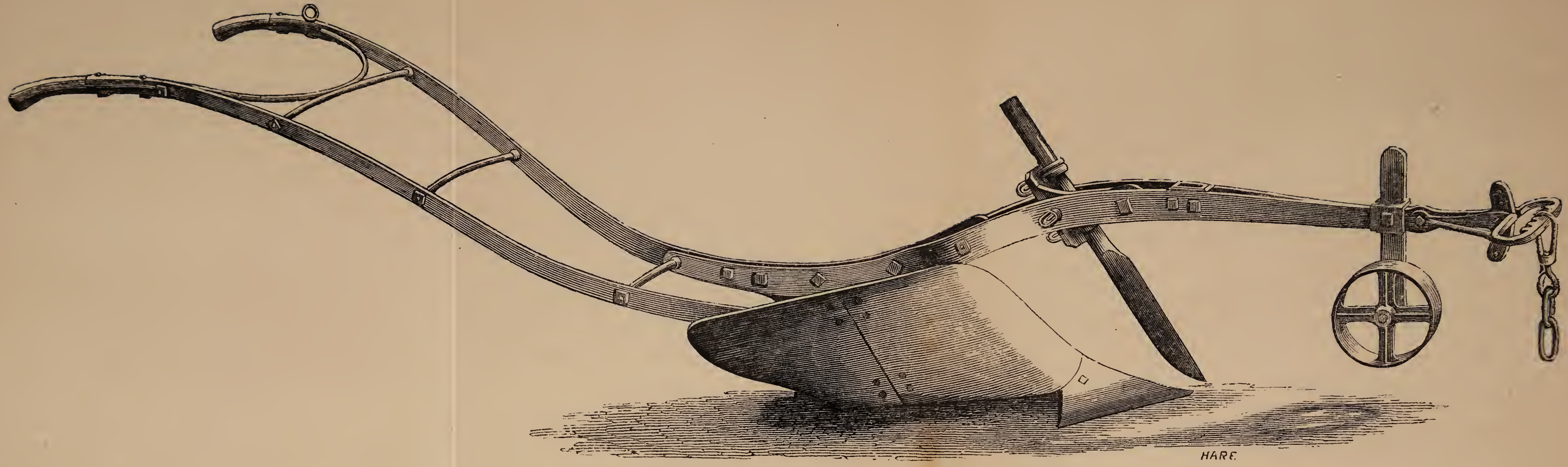
CHAPTER VI.

ON IMPLEMENTS.

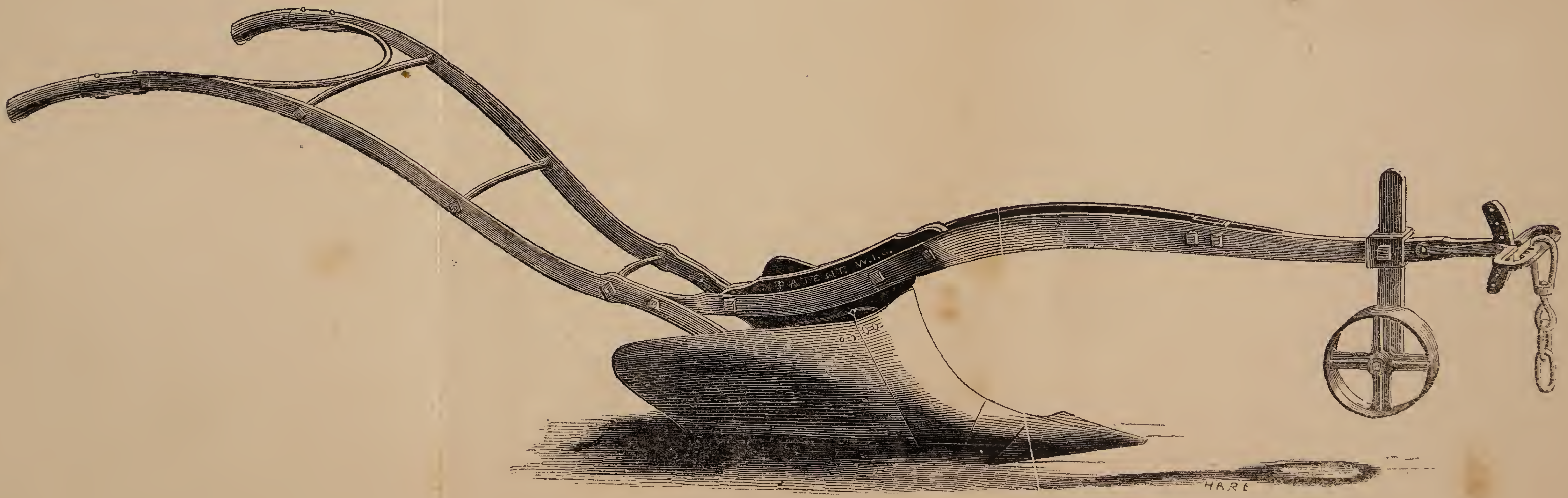
In commencing this chapter, it is necessary to state the object I have in view, and also to make a few remarks; that the reader may not misconstrue my motives.

This object, then, is to characterize a few of those implements that are useful and necessary to the sugar-planter; and, at the same time, to introduce to him those manufacturers, who, from their high reputation and acknowledged ability, are deserving of his confidence and patronage. In doing this, I must at once, and in the most emphatic manner, disclaim all intention of puffing any one's invention or workmanship. I am simply desirous of benefiting the planter by recommending him to those who will do him justice in every particular; and I can truly say that I am totally unacquainted (personally) with almost every manufacturer whose name I have hitherto mentioned, or shall have occasion to mention; being entirely guided, either by specimens of their work which have passed through my hands, or by the established reputation they have secured to themselves. In several instances I have gone as a stranger to their manufactories, inspected the various kinds of machinery, looked over their plans and drawings, and noted carefully the intelligence displayed. I have gone to them, in order to satisfy my mind that I am justified in recommending their work to the planting community; and I have selected those kinds of machinery which, from my own experience, I deem suitable to the planter. In performing such a duty there can be no favour, no partiality, no sacrifice of the honest independence essential in the writer of this

PLATE VI.



(Figure 1.) RANSOME'S PATENT SINGLE PLOUGH.



(Figure 2.) RANSOME'S PATENT DOUBLE TOM PLOUGH.

work. I shall therefore bestow praise and commendation only where I consider they are justly due; feeling confident that I am acting for the general benefit of the planting interest. As I am in no way connected with, or otherwise interested in, any of those manufacturers whom I have already mentioned, or am about to name, so am I quite incapable, both from principle and from lack of motive, of expressing an opinion which does not arise from my own unbiassed convictions.

The first implement which I find myself called on to notice is the very beautiful prize plough of Messrs. Ransomes and May's manufacture. (Pl. VI., Fig. 1.)

In appearance this implement is the most elegantly formed of any plough I ever beheld; and it happens that, whether worked as a swing, single wheel, or double wheel plough, it entirely surpasses every plough that has endeavoured to compete with it. Nor is this the only singular feature in its construction; for, to the great astonishment of numerous spectators, it was proved to be not only the best plough under every circumstance in light soils, but also the best in heavy soils likewise.

The Journal of the Royal Agricultural Society of England contains a full statement of these extraordinary results, and it was unanimously declared to be due to the correct principles of its construction. The remarks of the journal named are very interesting.—"When fitted with two wheels the performance of Messrs. Ransomes' plough was like that of a planing machine; the furrow slices were cut vertically from the land, the floors or bottoms were left perfectly flat and clean, and the slices were deposited at an angle of about forty-five degrees, with such truth that they could be turned back to their original horizontal bed without gaining or losing ground. According to the generally received principles of perfect ploughing (whether they be correct and equally suitable to all soils and modes of culture or not), it is imagined that practice has, in this instance, closely approached to their fulfilment. When fitted with one wheel, though the work of the plough was excellent, yet there was a deviation from that extreme regularity and finish belonging to the two-wheeled performance. When acting without a wheel this deviation was still more plainly discernible, which is directly traceable to the influence exercised over the motion of the plough by the motion of the draught animals; but it still performed work greatly superior to any of the other ploughs similarly circumstanced," &c. &c.

In consequence of the superiority of this implement in every trial, the judges awarded the several prizes to Messrs. Ransomes and May for this one plough.

The next is a patent trussed beam double-tom plough, also the invention and manufacture of Messrs. Ransomes and May, of Ipswich. (Pl. VI., Fig. 2.)

This is constructed on the same principle as the foregoing; but it has a pair of mould-boards—a right and left-hand one—which expand in the same relative degree with each other. The share has also a right and left wing. Its use is principally to follow the single plough and open wide the trenches for the reception of the cane-plants—in doing which it makes a neat trench, throwing up the earth lightly on both sides at once; to plough deep trenches, to serve as water furrows at regular distances apart in a field: also, by taking off the mould-boards, it may be used as a broad-share plough for cleaning land, or as a subsoil plough.

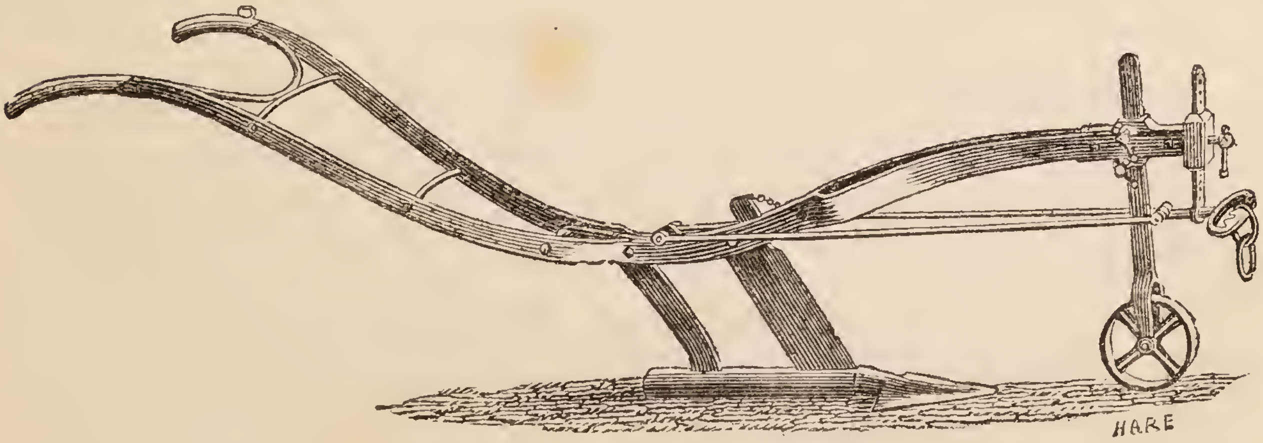
Messrs. Ransomes have also adapted to it a large revolving coulter with a steel edge made sharp, with the view of cutting through the cane-trash lying on the field, so that it may be buried at one operation; the coulter being made to take off when not required. I have, however, very great doubts as to the revolving coulter answering the expectations formed of it.

The following extracts from the Journal of the Royal Agricultural Society of England (vol. iv. p. 467), are well deserving the planter's perusal and consideration:—

"They (the judges) would particularize, as worthy of high commendation, those (ploughs) produced from the manufactory of Messrs. Ransomes, composed entirely of iron and steel. The beams of these ploughs are constructed on the truss principle; which, though novel in its application to the plough, has long been appreciated by mechanics, as possessing the greatest stiffness, combined with lightness. It is this consideration which has induced those makers to abandon the use of wood, hitherto used by them for this part of the plough, in favour of a beam of solid metal. The structure of their improved iron beam is such as to destroy lateral vibration, particularly at its root or juncture with the body of the plough; it admits also of a neat and powerful fixing, as well as ready adjustment of the coulter. * * * *

"It is also important that the handles or stilts should be stiff enough to transfer the effect of the holder to the body of the plough with the least expenditure of his strength; for the easier its guidance, the greater will be the certainty of the labourer's attention to his business. This property has also received the care of Messrs. Ransomes, and, together with the simple means applied for adjusting and replacing the mould-boards, shares, and wearing parts of the various ploughs exhibited by them, testifies to the thought and ability bestowed on the most minute details of an implement, which still maintains its claim to be the most indispensable, as it was probably the earliest invented, auxiliary to human labour in tilling the soil."

The "Rackheath subsoil plough" invented by Sir Edward



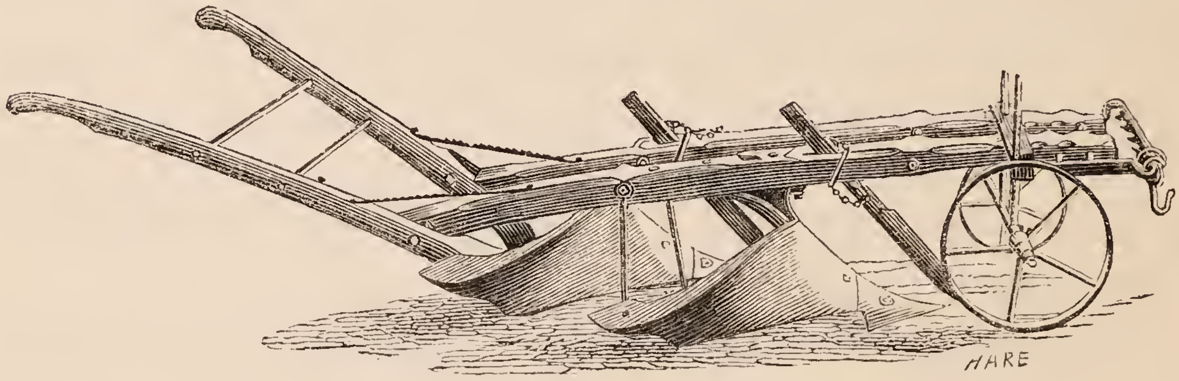
The Rackheath Subsoil Plough.

Stracey, Bart., and manufactured by Messrs. Ransomes, is an implement highly useful to the planter for subsoil ploughing.

It performs this operation to the depth of from fifteen to eighteen inches below the surface; but when preceded by the common plough, which is the plan recommended, the depth reached below the surface is increased to the extent effected by the first plough.

As subsoil ploughing is so much required on sugar estates, it behoves the planter to provide himself with a really effective implement of this class; and I know none more likely to suit him for lightness, strength, and utility, than the "Rackheath plough."

The next implement is what is termed "the double-furrow plough," and in light soils, or where great power is available, (as in the case of ploughing by steam, by elephants, &c.), its use is very desirable indeed; as it ploughs two furrows at once, and can consequently get through double the work of a single-furrow plough, and that too by the addition of only half as much power as is required to work the single plough.

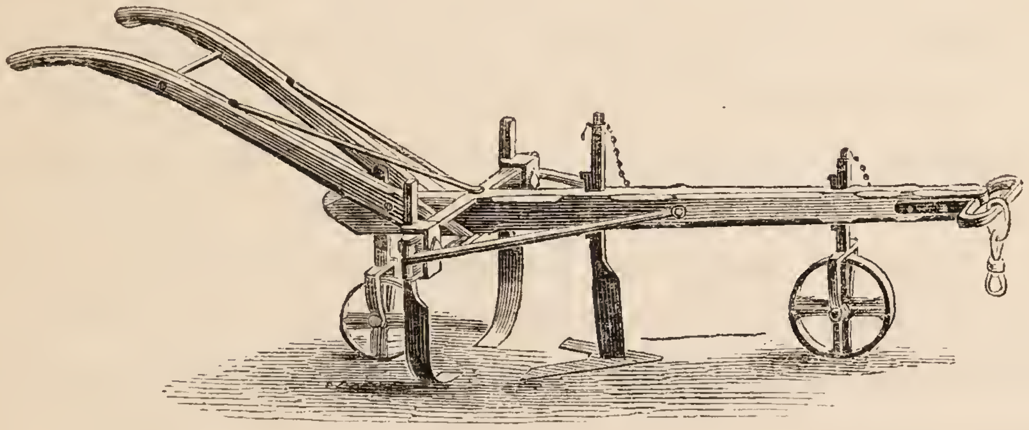


The Double-furrow Plough.

In England, wherever it has been used (on light soils) it has been found to answer admirably; performing as much work with three horses, one man, and a boy, as two ploughs with four horses and two men can accomplish. A farmer residing near Ipswich, has three double-furrow ploughs at work, of which he gives the following interesting account:—

"With three horses abreast and one man only, he can plough double the quantity of land per day that he can with a single-pair horse-plough: in other words, he ploughs with his double-furrow plough two acres instead of one; thus saving the labour of a man and a horse. The work is rather harder for the horses, but not worth mentioning. He ploughed thirty acres in fifteen successive working days, and the horses did the work without being in the least hurt by it. The ploughmen did not at first like these ploughs, but they soon became reconciled to them. The land in which they were used is light, but inclining to what is termed a mixed soil or sandy loam. The furrows are nine inches wide by six deep."

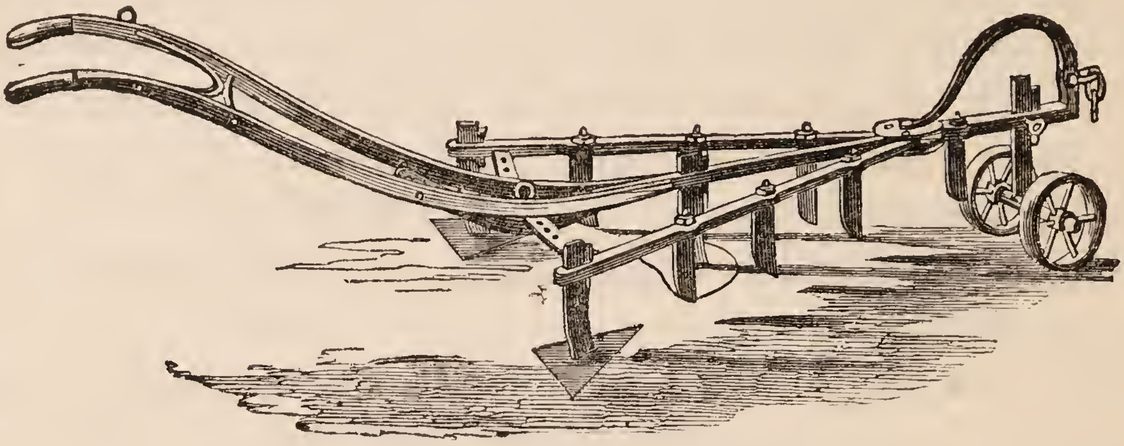
The hoe-plough is the next implement particularly deserving of attention; indeed it is one of the most useful the planter can employ.



Hoe-plough.

This plough is used for the purpose of hoeing up weeds and loosening the earth between growing plants. It is provided with two wheels, one in front of, and one behind the hoes, by means of which the depth of the hoeing is regulated. It may be used with three triangular hoes, each cutting thirteen and a half inches wide, extending over three feet six inches of ground, or contracted to a smaller width; or the two hind hoes may be replaced by two curved knives (as shown in the above engraving) for cutting the weeds up on the sides of the ridges. It is an implement of very simple construction, and in great use in England; it is also one which will be found of very great advantage on sugar estates, in cleaning between the cane-rows, and in loosening the soil about the plants.

"The expanding horse-hoe" is an implement designed and manufactured expressly for the colonies, and is already beginning to establish for itself a very sure reputation amongst sugar-planters.



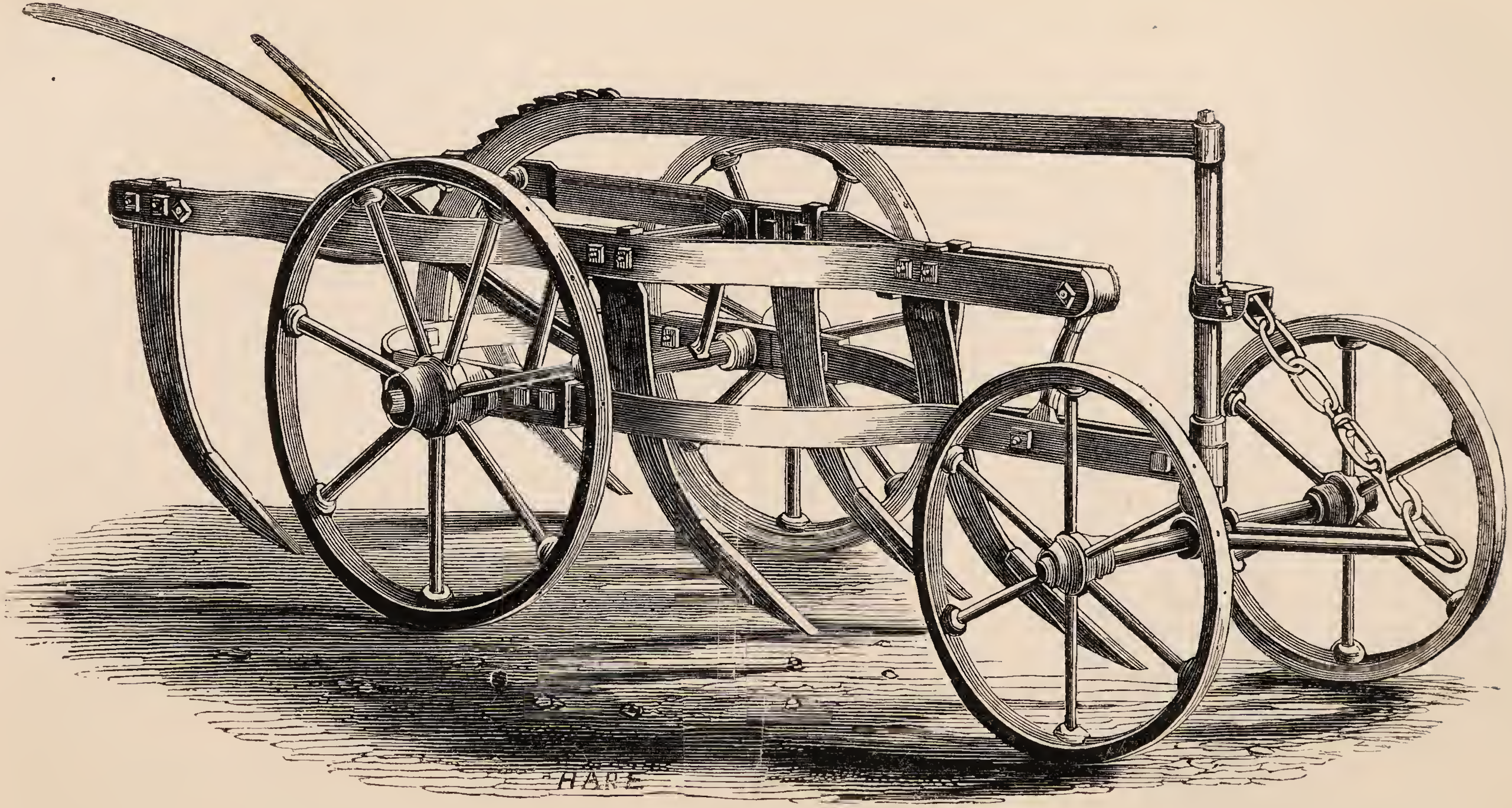
Expanding Horse-hoe.

By means of a very simple contrivance, it can be extended and contracted at pleasure; so that the planter can have them made to expand even to five and a half or six feet, if he requires it: as he will, in all cases where he plants his canes at six feet apart; whilst, at same time, by having spare tines or shares of peculiar form, he can vary the nature of the work to be performed by it. For instance, the implement as now shown, is suited for rooting up weeds and loosening the soil between the rows of canes; but by taking off the tines and hoes represented in the engraving, and replacing them with light moulding shares, the instrument is at once converted into a moulding machine, whereby the young canes may receive two or three successive mouldings as lightly and neatly as by hand labour.

I consider this machine to be so valuable to the planter, that no sugar estate should be unprovided with them; it enables him to perform at a very inconsiderable cost an amount of work which, when executed by hand labour, is well known to be very tiresome and expensive.

The next implement which is of peculiar value to the sugar-planter, is Ransomes' "Patent Indian Cultivator." (Plate VII.) I am pleased to know that this excellent instrument has obtained for itself a very considerable celebrity in the West Indies.

PLATE VII.



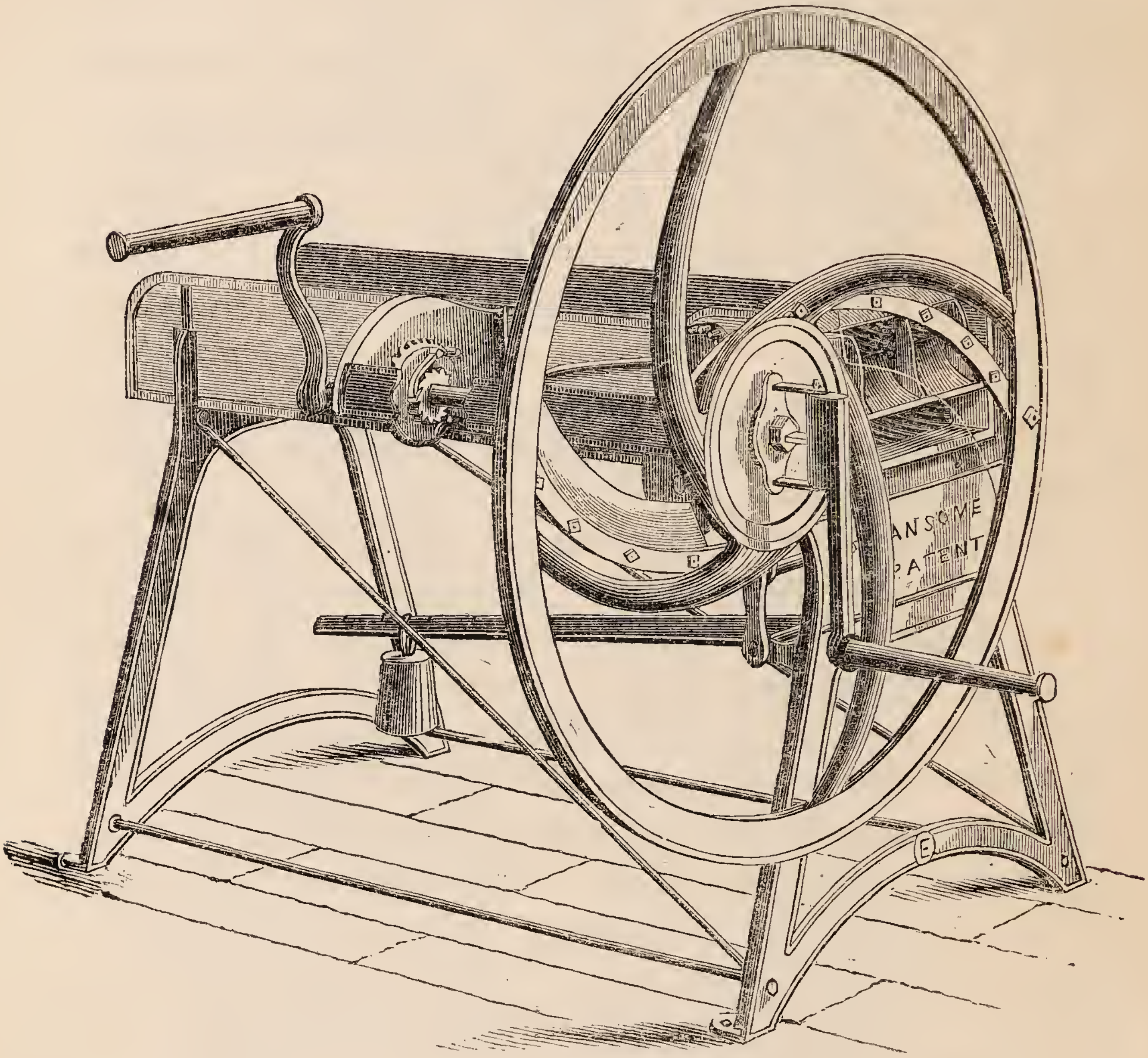
RANSOME'S PATENT INDIAN CULTIVATOR.

This implement has obtained the highest commendation after a thorough trial, and will be found capable of a variety of operations. It readily penetrates very hard earth, tearing up roots and weeds with ease and certainty. By passing it at right angles across foul ground, it thoroughly disintegrates the soil without the necessity of ploughing; and with the aid of a clod-crusher, almost any land may be brought into a clean state of fine tilth. The teeth are made of wrought iron, with case-hardened points, which can be renewed as they wear; so that the implement is extremely durable, being composed entirely of metal. The points being removed, hoes can be substituted that cover the ground; and as, by the action of the lever, the depth can be adjusted to the greatest nicety, it then becomes a hoe, effectually cutting up all weeds in a track of more than three feet in width.

The perfect manner in which this machine acts, and its utility in various stages of cane cultivation, appear so great to the Council of the Royal Agricultural Society of Jamaica, that they have adopted a representation of it on their prize medal; and have presented Messrs. Ransomes and May with one of these medals, as a testimonial of their approval of the efforts made by those eminent manufacturers to improve the various implements used in agriculture. The patent Indian cultivator was constructed expressly for the use of sugar-planters; and I am happy in being able to record my opinion as entirely coinciding with that of the Council of Agriculture in Jamaica, in regard to its merits.

The last machine made by these manufacturers, which I have occasion to mention, is "The Patent Cane-top Cutter."

This engine has been made purposely to suit the wants of a sugar estate, as cane-tops are so generally used for feeding cattle in the West Indies: but I may once more observe that the practice of using cane-tops for fodder is wrong in every sense, and should never be allowed on any estate. I make the remark, because I know that the time is not distant when every planter will become convinced of the correctness of my assertion: but at present, and for some time to come, I fear the injurious practice will be persisted in; therefore it is that I make mention of a machine which should never be used on an estate for the purpose it now is.



Cane-top Cutter.

Were the planters to use it, or others similar to it, for cutting chaff for their cattle, instead of cane-tops, then it would be appropriated to its own peculiar and proper purpose. However, as cane-tops will yet no doubt be used by many, and as this machine is certainly much superior to all others of the same class, I cannot do less than give a brief description of it. This cane-top cutter is made entirely of metal;

thus avoiding the inconvenience and damage which result to machines constructed partially of wood. It is furnished with two knives, cuts lengths of half an inch, and requires only the most ordinary care in keeping the wearing parts oiled and occasionally cleaned. It can be worked either by one or two persons; requires no skill; and, if kept free from stones and other extraneous substances, is not liable to injury, but has been found to be a very durable machine.

The bearings should be kept clean, and oiled with sweet oil. The knives are best sharpened with what is commonly called a saw-file. Two sizes are made, of which one of the smaller has been sent to Jamaica as a specimen: this is marked E, and the larger one D. A machine of this kind saves a great deal of labour which is often wastefully expended in cutting tops by hand labour.

The next machine to be described is a steam-dredging machine, expressly adapted for the purpose of excavating, deepening, and cleansing canals, and draining trenches, in the colonies of Demerara, Berbice, &c. &c. It is manufactured by Messrs. J. and A. Blyth, of Limehouse, who make them of any size or power that may be demanded by peculiar circumstances. The machinery is contained in a boat, which floats in the canal or drain to be cleansed, and pulls itself along, either backward or forward, by means of chains run out from the bow and stern, and secured by anchors.*

When at work, the buckets descend the required depth into the mud, and on rising discharge their contents into an inclined gutter, which conveys it to the bank where it is deposited. In forming a new canal, the roots and stumps of trees existing in the track lined out must be dug up and cleared away; a space sufficiently large to admit the machine is dug, and water allowed to flow in to float it; the boat is then introduced, and the machinery set going, when it will cut its way along, forming the canal (of the desired depth and width) as it proceeds. The chains are moved forward each time the engine has drawn itself to the place of anchorage; so that in the course of day, this machine will work up to many lengths of the chain, performing a large amount of work at very little expense.

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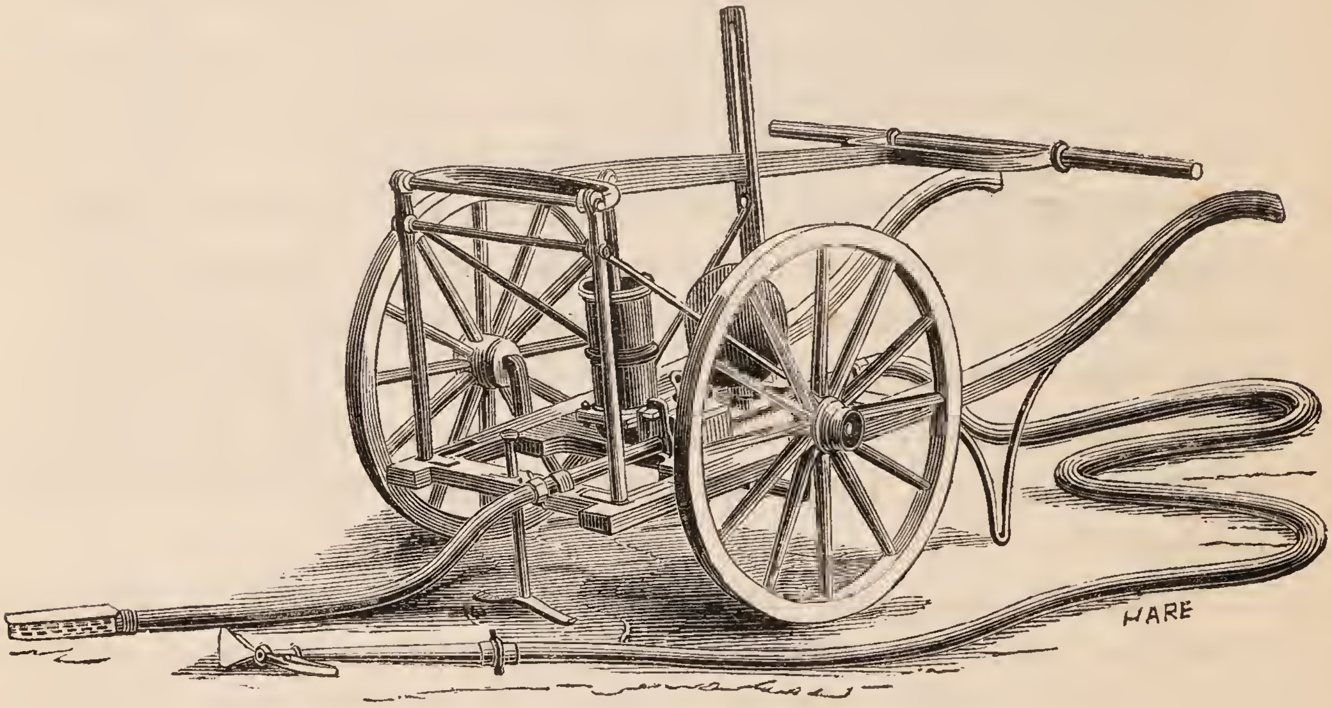
* This machine will be perfectly understood from the above description.

In excavating new canals, and keeping old ones clean when on a large scale, the use of such a machine must be attended with a very considerable saving, both in expense and time; and it appears to me that there can be no difficulty in so constructing the boat and machinery as to render it available for very many purposes besides those stated.

At page 256, I have made mention of a small fire-engine or irrigator, invented by Mr. Baddeley, and I have now the opportunity of giving a representation of the machine.



Fire-engine and Irrigator.

This is an exceedingly simple well-contrived machine, either for extinguishing fires, or for irrigating lands; in both of which capacities it is likely to be of very great utility to the sugar-planter.

I would draw attention to it more particularly as an irrigator, because it is admirably suited to the necessities of an estate that has to be much irrigated; and when worked in connection with the wind-mill, or steam pumps (before recommended), will distribute the water over the fields much more equally, expeditiously, and economically, than can be done by any other method. Where the plan of permanent (pipe) water-ways is carried out, a few of these irrigators, taking up positions at the different nauds (lying along the water ways), would most expeditiously water the lands within their range; moving on from naud to naud until the whole field was finished. It is made very light, so that three men run along with it over fields to the different receptacles for water, drop the suction pipe into the water, and pump away, sending the water over the land in fine jet or shower.

It must be apparent that if pumps are working at the wells, ponds, or rivers, and delivering, say five hundred gallons of water a minute, it would take a great number of people to scatter that amount of water over the field in a manner really desirable; whereas, with two or three of these machines, with only a very few men (three to each), the work may be accomplished in the most perfect and economical manner.

The cost of one of these irrigators, to be worked (easily) by three men, is only 25*l.*; and the admirable principle on which it is constructed ensures its satisfactory working and extreme durability. It is described as being applicable to the roughest work of an estate, without any fear of injury; whilst no part of it requires more care and attention than that usually bestowed on a common cart wheel.

At pages 72 and 75, I have alluded to the use of a "levelling-machine" for levelling the banks of canes, and covering up the cane-trash and long-tops. I must now proceed to give a rough description of its construction and peculiar action. The machine consists of an iron cylinder, somewhat similar to a garden roller, to the framework of which are affixed two arms, preceding the roller; these gather the cane-trash, and place it in a position to be pressed down by the roller; whilst immediately behind the roller are two cutters or ploughs, which slice off from either bank portions of earth, and by means of the mould-boards arrange them cleverly over the cane-trash.

Thus in planting in lines 6 feet apart, the canes would receive in banking successive portions of earth, until the banks had become about 3 feet broad at the base, 1¼ ft. at the top, and 2½ ft. high; the space then left between the base of the banks would therefore be only 3 feet, which accordingly is the breadth of the roller. Now, when a field of cane is cut, and the leaves and trash of all kinds are laid in the trenches (as recommended at page 72), this machine being introduced between the banks and its cutters or ploughs properly adjusted (by means of an expanding contrivance), the roller passes over the mass of cane-trash which it compresses, and the cutters or ploughs cut off from each bank the desired quantity of earth, which is made to fall over the trash so as to cover it up. In each succeeding trip the cutters are expanded, in order to take off a further quantity from each bank, until they are so much reduced that but little is left to cut down by hoe, as is spoken of at page 75. Thus the machine proceeds up one trench and down the next, alternately, until the field is finished; altering the expanding apparatus each time to suit the case. It is necessary for me to say, that I have never seen such a machine at work: but it is one of my own contrivance, which I intended expressly for the work specified; and I have a very firm belief that it will be found to answer the ends proposed very well indeed; and if so, there can be no doubt as to the saving of time and expense it would effect in the work of an estate.

In concluding this chapter, I find it necessary to advert to some remarks that I made at page 119; and to add a few observations on the subject of bringing out canes from, and distributing cane-trash, manures, &c., throughout the fields, by means of the endless band, worked by the locomotive steam-engine and its assistant. Instead of hooking on bundles of canes, &c. &c. to the band as there supposed, it would be better, and more practicable, to use the band for drawing the light carts mentioned at page 71. These could be drawn, by means of the engine and band, along the trenches until they were filled with canes; then, by reversing the engine, they would be drawn out to the road and emptied; returning again immediately for another load, and so on until the cane-wagons in the road were loaded; when the locomotive would take them to the mill-yard.

In distributing cane-trash, sand, manures, &c. throughout the field, the same means would be employed; only they would then take out loads, and return empty.

I have now gone over the whole detail connected with the cultivation of the sugar-cane plant: but previous to entering on the manufacturing branch of my subject, it is necessary to offer a few remarks on the expediency and cost of having railways or tramways on a sugar estate.

Impressed with a full conviction of the importance of the subject, I have made it a point to consult various engineers of acknowledged ability, as to the lowest possible rate at which an efficient system of railways might be carried out; and the following results I have deduced from the information and plans politely furnished to me by Messrs. J. and A. Blyth, the well-known engineers and manufacturers at Limehouse.

One great principle which it is necessary to recognise is, that no greater weight than about one ton need be contained on each wagon used on the railway; but that there may be three, four, or even six wagons attached to each other and working together; by which means the three, four, or six tons weight of canes or other matter would be distributed over a considerable extent of rail, and consequently would admit of a very light, portable rail being used. It is on these premises that the following calculations are based.

The longitudinal bars or rails are each 12 feet long, and weigh 36 lbs. which gives for one mile of the rail line, a weight of 14 tons. These rails rest on flat plates of wrought iron, six inches broad, and one-eighth of an inch thick, which would weigh about eight pounds each; and as the length of each rail is 12 feet, three of these plates are allowed to each rail as bearings, viz., one at each extremity, and one in the centre, making six feet bearings. The weight of the bearing-plates would therefore be nearly five tons, per mile; which, together with the 14 tons of the rails, gives a total weight of 19 tons for one mile of such railway; this, at 12*l.* per ton, brings the cost to 228*l.* in England. The rails are affixed to the flat plates by means of screw rivets, and are, when laid down, three feet gauge.

Now, to carry out this system economically and practically, I will take as an instance, an estate of 640 acres, planted out in canes; and for the sake of ready illustration, suppose the land to be a square, with the manufactory in the centre. We then have a square mile; which I would divide into ten parts, by means of nine rail-tracks running parallel to each other, at a distance of about 528 feet, or about 2½ acres apart; all these lines being connected by means of a cross line, running across the centre of the estate, and passing immediately before the mill-yard. But ten railways would be very expensive if laid down complete; therefore the most economical plan would be to have flat plates for bearings, sufficient for five miles of line and two miles of rail; costing in all 636*l.* The five miles of bearing-plates would always be laid down wherever required, being taken up and removed from track to track as might be necessary; the two miles of rails also would be moved about as may be desirable. Thus, when bringing home canes from the most distant part of the estate, one mile of rail would much more than suffice; leaving upwards of one mile more to be laid down wherever it might be required to carry on other work. In removing the plates and rails, one wagon, drawn by a mule or two bullocks, and four men, would be quite sufficient to take up and lay down in another place, half a mile of line in a day. The wagon would always run on the rail, whether in taking up or in laying down, and would carry each trip from one to 1½ ton of rails and plates; two men would either screw up or unscrew the rivets, whilst the other two lay down and properly adjust, or take up and place on the wagon, the plates and rails; and if either set works faster than the other, then they must help each other.

I have stated the cost to be 636*l.* for five miles of plate bearings, and two miles of rail line; but to this sum must be added, I will suppose, 64*l.* for curved pieces, extra rails, plates, rivets, nuts, claws, &c., &c. and 100*l.* for freight, and charges of all kinds, which gives a sum of 800*l.*

To render the plan entirely complete, we next require three locomotive steam-engines running on the railway; one of which, in crop time, would draw out canes to the road, and distribute the green cane-trash throughout the field, as mentioned at page 280, besides drawing the wagons backwards and forwards between the mill-yard and the field; and the other two would be employed in ploughing, levelling banks, or whatever work might be required. The cost of these three locomotives, of six horse-power* each, would be about 1,000*l.* if honestly made; which being added to the before-named sum of 800*l.* brings it to a total amount of 1,800*l.*

The question, then, is, what have we got for this outlay? It appears that we obtain the means of the most rapid and efficient transport, both for our canes and for the green-trash, sand, manure, or indeed whatever else we may wish; as well as being possessed of three powerful machines, in the locomotives, which will transport themselves wherever we require, and perform all the varied labours stated at page 117: except the fourteenth item. It also appears that we get rid entirely of the numerous herd of cattle usually kept on sugar estates. On reference to pages 65 and 68, we see what the food of cattle costs in Jamaica, if kept even on the most approved and economical system; and we find that a sum of 300*l.* a year is necessary to support the number sufficient to work an estate of 150 acres in canes; whereas, with three such locomotives, and the railway calculated for, we can keep in excellent cultivation 640 acres of land, and transport all the canes produced to the mill, without any difficulty whatever. The first cost is not a very large sum, and as to the economy in every way effected, I fully believe that, by the second year, the saving would be so great as to repay the whole of the original cost. It must also be observed that by paying proper attention to the treatment of the iron railway, all rust may be prevented; and it will consequently last for a number of years.

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* Six horse power nominally, but capable of being worked up to eight or ten horse power.

CHAPTER VII.

ON THE CONSTRUCTION AND ARRANGEMENT OF A SUGAR AND RUM MANUFACTORY, COMPRISING AN ACCOUNT OF THE MILL, BOILING, CURING, AND DISTIL HOUSES, TOGETHER WITH THE MACHINERY AND APPARATUS TO BE USED.

The first material point in treating of "the works," is that relating to the construction and peculiar arrangement of the building. The endeavour, in all cases, should be to secure a sufficiently roomy, yet compact form; to make each department bear the most desirable relative position to the others; and to bring all, as nearly as may be, under the eye of the superintendent at once.

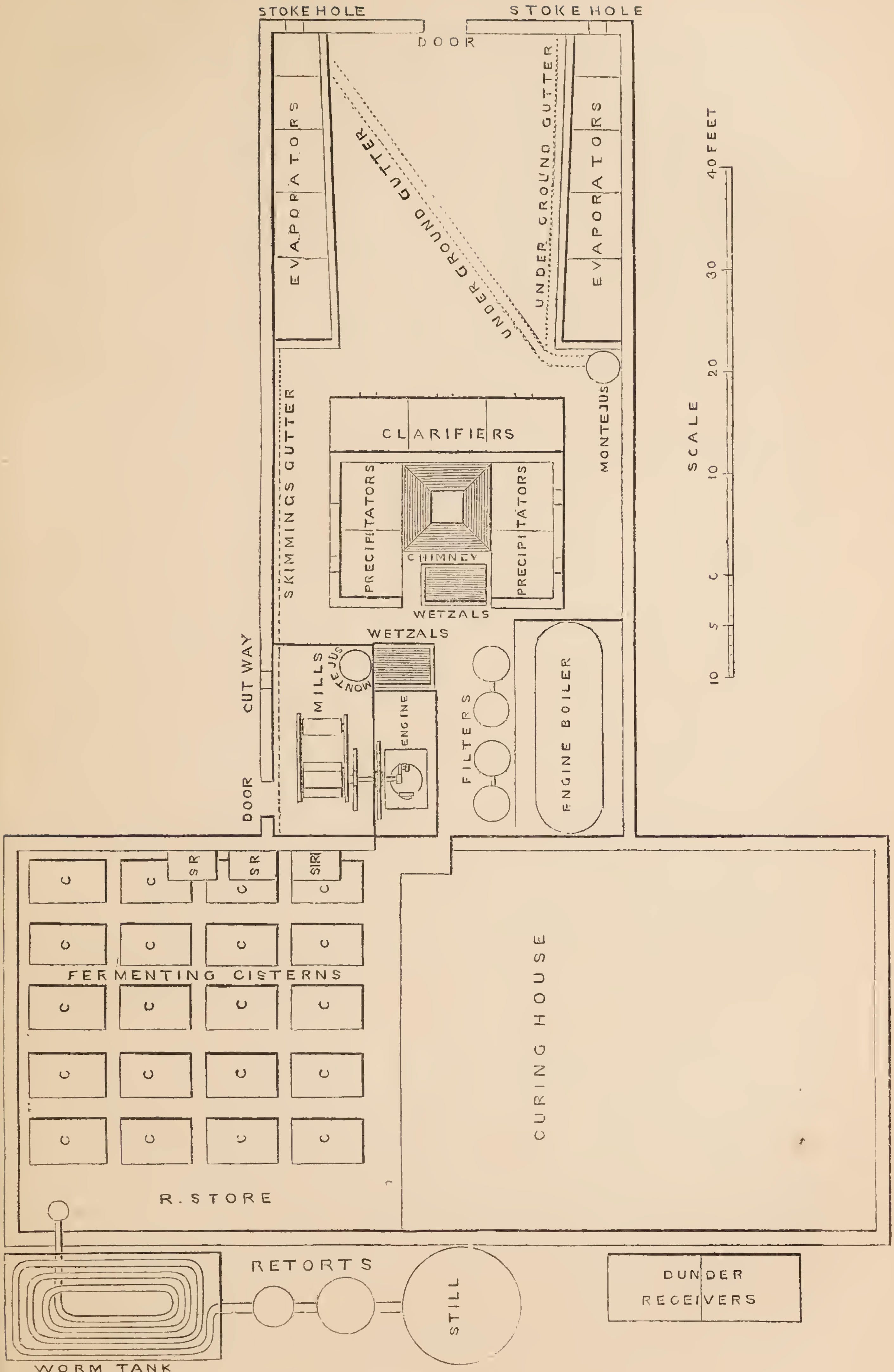
In Jamaica, it is very rare to find any two estates with their manufactories similarly arranged; and the old-time buildings, which were erected in the time of slavery, are found to be serious stumbling-blocks, now that labour is scarce and expensive, and competition presses so hardly on the planter. It of course occurs, that the more compact and perfect the general arrangements are, the more satisfactory and economical its working details will prove. It is difficult to particularize any plan of manufactory as being peculiarly West Indian; for when I left that part of the world, there was no fixed plan, but each estate seemed to have an arrangement of its own.

In the Mauritius and the Straits Settlements, the case, however, is somewhat different; there they very generally prefer one long narrow building, with the engine-boiler first, then the engine and mill, next the clarifiers and boiler ranges, then the curing cases, and last of all the distilling department. As may be supposed, the building requires to be very long indeed; so that, although the planter can see from one end to the other, yet nothing less than the aid of a telescope would enable him to determine what may be going on at the further extremity of the building. It has often been a matter of surprise with me, that any planter should fix on so undesirable a form for his manufactory; as it entails a very great deal of inconvenience and extra labour, necessarily creating a corresponding increase in the expenditure of the estate. Without dwelling, however, on the folly but too frequently exhibited in this respect, I will proceed to represent two forms or plans which offer many advantages.

Plate VIII. is the plan of a manufactory, capable of making five tons of sugar in a day of twelve hours, fair boiling. That part of the building occupied by the curing and distilling departments, is 85 ft. long and 40 ft. wide; whilst the other occupied by the milling and boiling departments, is 80 ft. long by 36 ft. wide. The mill-house shows two mills; or rather one set of three rollers, and another set of only two rollers.

The expressed juice is allowed to run into the monte-jus, which raises it to a gutter, placed above it sufficiently high to admit of the juice running into either of the three clarifiers, from whence it is drawn down into the precipitators. The liquor is next conducted by gutter into the evaporators, where it is boiled down into a syrup, which is discharged from the taches into under ground gutters, and conducted into the second monte-jus; this raises it into a receiver placed above, at an elevation sufficient to allow of its being conveyed by gutter into the charcoal filters (near the engine boiler). Here the syrup is decolorized, and, passing through the

PLATE VIII.



PLAN OF MILL, BOILING, CURING, AND DISTIL HOUSES.

filters, falls into receivers immediately beneath them, whence it is drawn down by gutter into the concentrating apparatuses, named in plate "Wetzals." This kind of apparatus was introduced into the island of Bourbon some years ago, from whence it was adopted in the Mauritius, and finally came into general use in Province Wellesley. It is there termed "Wetzal's pan," or concentrating apparatus, from Monsieur Wetzal, who first recommended its use in Bourbon. The same kind of pan is in England known under the name of Gadesden's patent pan; but I am not aware who is the real inventor of it.

From the concentrating pans the concentrated syrup is conveyed into the curing-house, and deposited in appropriate vessels. The engine-boiler in this case works the engine, supplies steam to the wetzal near the precipitator, works the monte-jus when required, and cleanses the charcoal filters, by injecting steam through them as often as is necessary.

The evaporators are supposed to be of sheet iron, and flat bottomed, containing in each range 1,600 gallons of liquor; and are worked by furnaces in the usual way. The heated air, after leaving the evaporators, passes under the clarifiers, when they require to be heated, or at other times up the chimney direct. The clarifiers are provided with dampers and fire places; the latter for the purpose of heating the pans before fire is "called" in the furnaces of the evaporating ranges. The precipitators have each a separate fireplace of their own, and have no connection with the furnace-flues of the evaporators.

The wetzal pan next to the engine is heated by the escape steam from the engine, whenever the engine is working; and both of these pans are worked by bands which pass from the engine over their drum wheels. If the two wetzals are not able to concentrate the syrup fast enough to keep pace with the evaporators, nothing can be more easy than to have another erected just inside the curing house.

The chimney is the one general chimney of the whole factory; serving alike for evaporators, defecators, and engine boiler.

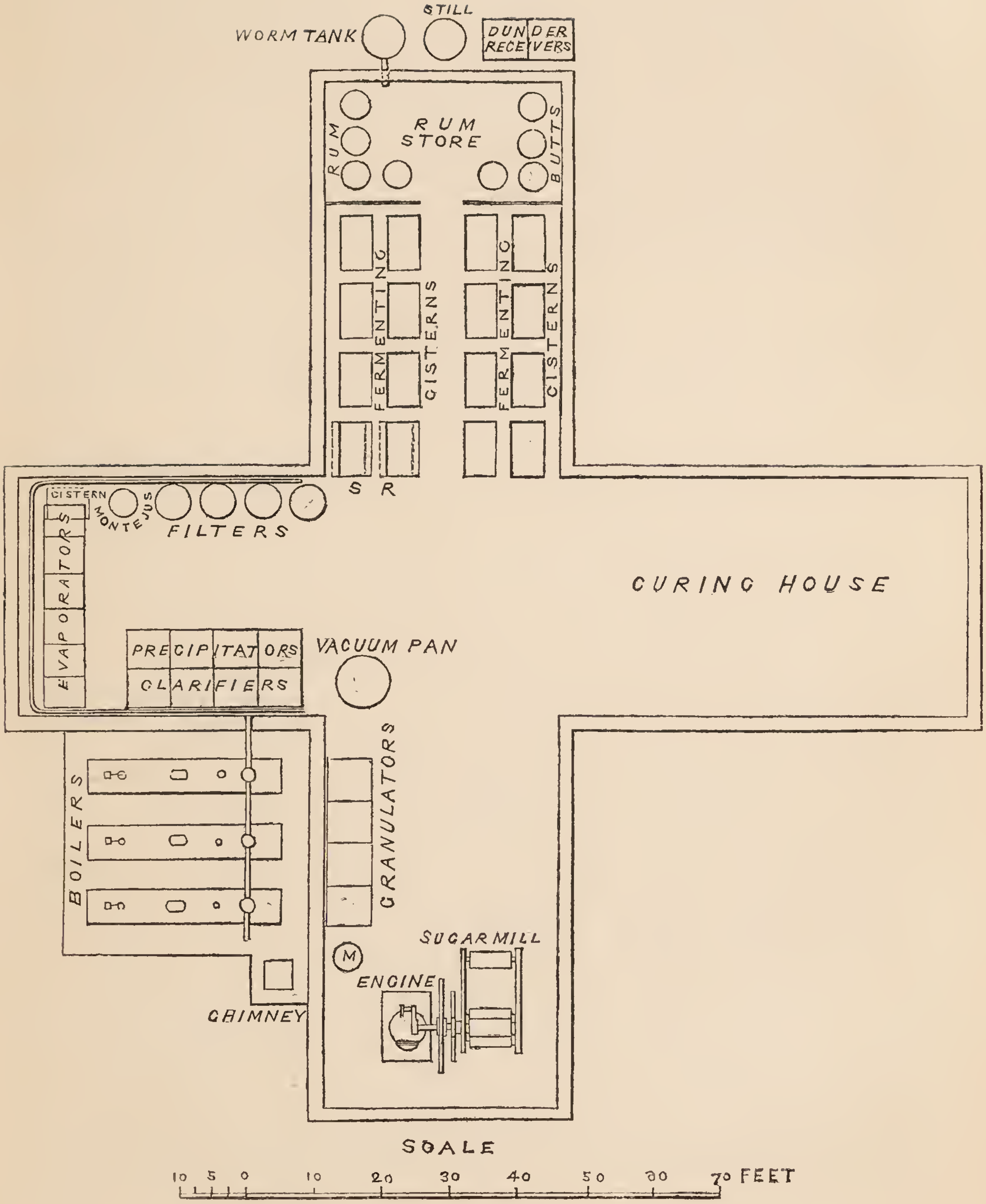
The skimmings (or scummings) gutter, conveys the skimmings from evaporators, and the scum and dirt from the defecators, into the three skimmings-receivers in the still-house; to be used in making rum.

The still-house shews twenty fermenting cisterns, sunk in the earth: each holding one thousand gallons; whilst outside the building, the still and two retorts are seen, together with the worm tank, and two dunder receivers; which last have, directly below them, other two dunder receivers.

In this plan the whole of the working detail is compact and well connected: each part leads to the other in a simple and easy manner; labour is economized, and business expedited.

Here, as I shall have occasion to allude to it more minutely as I proceed, I will now introduce another plan; involving a larger outlay of capital, but of a very superior character.

Plate IX. represents a building in the form of a cross; each wing being appropriated to a separate department: as the mill, boiling, curing, and distil-house departments. First, we have three steam boilers, to work the engine and supply steam to the whole of the manufactory; the engine, of sixteen-horse power, works the mill and air-pump of vacuum pan; the mill is provided with two extra cylinders, as in Plate VIII.; and the expressed juice runs into the monte-jus, which raises it up to a receiver, whence it runs into the clarifiers. When clarified, it is drawn down into the precipitators; which, as well as the clarifiers, are worked by steam. From the precipitators the cane-liquor is conveyed by gutter into the evaporators; which are six sheet-iron pans worked by steam, and holding 450 gallons each. When the liquor has attained the consistency of syrup, it is drawn down or skipped into the receiver (shown by the dotted lines) and raised by the monte-jus into the charcoal filters, whence it passes into the vacuum pan, in order



IMPROVED PLAN OF A MANUFACTORY, WORKED BY STEAM.

to be concentrated. This operation being completed, the concentrated syrup is run off into the granulators,* and finally is placed in curing-vessels in the curing-house.

In the *distilling-house* are four skimmings or scummings' receivers: two above and two below; so that only two are to be seen in the plan: they are indicated by the dotted lines, marked S R.

It next contains sixteen fermenting cisterns sunk in the earth, each holding 1560 gallons.

The rum store is shewn to be sixteen feet by thirty-six feet; which, small as it appears, is quite large enough in these days, when rum is sold as quickly as possible after it is made.

The *still* intended to be represented is one of Shears' patent; and the dunder receivers have below them two others of equal dimensions, from which the dunder is pumped up when somewhat cool.

With this brief explanation of the general form and arrangement, which I consider to be best suited to the requirements of a sugar estate, I will next take a view of the several departments, separately. The first is the *mill-house;* and comprises the motive power which propels the mill, and the mill itself. The power may be water, wind, cattle, or steam; the employment of either, being almost wholly dependent on the peculiar circumstances of the case. *Water*, is without question the most desirable means whereby a sugar mill can be worked: it is the cheapest, the safest, most manageable, and most enduring power, we can desire; and is beside the more valuable, as the water, after having propelled the machinery, may be conducted over the estate to carry out a system of irrigation. The form of water-wheels is, I may say, of two different characters only,—viz. the common water-wheel, whether overshot, breast, or undershot; and the horizontal wheel of Whitlaw and Stirratt.

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* The waste steam from the engine may be used for heating the granulators, if desired.

The undershot water-wheel is (except in very peculiar cases) a very undesirable form, and it is very rarely that its work is satisfactory. The breast-wheel is of a medium power and value between the undershot and the overshot; and in many cases it is very powerful and serviceable: but the best form is that of the overshot-wheel, where the water flows on the top of the wheel, and consequently imparts its whole weight in the most effective manner. Of late years the horizontal wheel of Whitlaw and Stirratt has been much spoken of, as being not only equal, but much superior, to the overshot; but I cannot readily bring myself to believe that such is the case. The following brief description of it may serve to convey some idea of its form and *modus operandi.* Resting on the ground-work or foundation, is a very strong iron box or receiver, into the centre of which a vertical hollow tube is made to fit (perfectly water tight), which acts the part of the shaft; its upper extremity working in an appropriate bearing furnished by frame work. To the receiver or box there is also a tube well fitted, that conducts the water (from whatever elevation may be available) to the box, from which it therefore rises through the vertical hollow tube or shaft, and passes off by means of two, three, or four arms, with which the upper part of the shaft is furnished. These hollow arms are made with a particular curve, so as to transmit the water with all due effect; and they are also provided with valves of peculiar construction, which are so contrived that they act the part of governors, regulating the speed of the engine. To set it in motion the slide of the supply tube is raised, and the water immediately rushes into the box, ascends the hollow shaft, and passes out through the curved arms, communicating (by the peculiar character of the curve and arrangement of the valves) a rotatory motion to the machine, which in a few minutes becomes very rapid indeed. At the lower part (or at any part) of the shaft, a toothed wheel is fixed, which working into another, belonging to whatever machinery may require to be moved, communicates to it its power. It is to all intents and purposes, a centrifugal machine, the principle of which has been most ingeniously and ably carried out: the weight of the water employed is made to exercise as great an effect as is possible under the circumstances; and the whole working detail seems to entail as little friction as can be expected from its peculiar form and the arrangement of its parts. I have never seen any of these wheels, except as drawings, but I have carefully perused a great many reports, as to their cost and the amount of power secured by them, as compared with the common overshot-water-wheel; and I am led to doubt, very much, the fact of their being capable of yielding a greater per centage of power than a well constructed overshot-wheel. The contrary is, however, stoutly maintained; and my own reasoning inclines me to the belief, that the horizontal wheel may certainly be preferable in every respect to the common breast-wheel: although I cannot, without actual and personal experience of the fact, consider it equal in power to the common overshot-wheel.

In the West Indies, especially Jamaica, water-wheels are very common indeed, and some of them are very powerful even as they now are made; but were the iron work to be made in England, and sent out, no doubt a very material reduction of weight and friction, as well as increase of power would result. I once resided on an estate in Jamaica, that was worked by an overshot water-wheel fitted to one of the old time—half wood, half iron, vertical mills; yet this mill, with all its imperfections, used to supply us with cane-juice to yield thirty-two tons of sugar in six days working, and could have performed much more had the boiling-house been able to keep pace with it.

The first cost of a water-wheel (in Jamaica at least) is considerable; but if well made and properly erected, its working is most simple, economical, and enduring, as well as uniform and efficient. I am of opinion that where an overshot water-wheel cannot conveniently be erected, the horizontal wheel of Whitlaw and Stirratt, may be availed of.

The *wind* furnishes another very great power, which planters have from time to time been eager to avail themselves of: thus, in Jamaica and many of the other West India islands, numerous windmills are to be seen, either in present working order, or in that state of dilapidation which has but too generally fallen on many of the finest estates of the West. Where the towers are still in good substantial order, mills could be readily fitted to them, in order either to work them in conjunction with cattle or steam-mills, or separately as a spell to those mills. No estate can rely on a windmill alone; therefore, wherever there is one erected, there is also either a steam or a cattle-mill beside. The expense of constructing a windmill is in general so great, and its work so very uncertain, that few planters ever think in these days of recurring to its use: but it happens that the only kind which has hitherto been tried in the Colonies is the vertical mill, the erection and general cost of which is very expensive. Lately, however, there have been patented more than one form of horizontal windmill, which seem to hold out a promise of better things for the planter. Of these, that of Stace and Vallance appears to be the best; and, next to that, Biddle's Eolian Engine (as he terms it); either of which may be purchased at 25*l.*, the four horse power mill. I am unable to speak correctly as to the price of those of greater power; but I have now before me a letter from one of the patentees (Mr. Stace), wherein he writes, that they can supply those windmills which are considered of four horse power with a moderate wind, at 25*l.* each. I therefore have little doubt that the cost of one which would be rated at sixteen horse power in a moderate wind, would not exceed 100*l.* Now if an honestly constructed and practically efficient windmill, of sixteen horse power, can be purchased for 100*l.*, I think every estate (favourably situated with regard to wind) should have one, whether the other motive power be cattle or steam. I consider that it would be found a very valuable auxiliary; one that would very frequently spell the cattle and mules, whereever they are still used; or would save a considerable amount of fuel where steam-engines are employed. I have myself lived for a long time on an estate which had a windmill, and I have, in numerous cases, known it to be in full work from daylight until dark. In Jamaica, however, the sea-breeze usually sets in at about nine or ten o'clock in the morning, and lasts until four or five o'clock in the afternoon; affording, therefore, from six to seven hours working wind. This sea-breeze is on the whole very constant, and very frequently is very powerful, as every planter knows. I therefore perceive that great economy of fuel would result, as well as other advantages so important, that I think the subject merits the serious consideration of the planter.

Let us look at the matter practically and dispassionately: take, for instance, an estate having a ten or fourteen horse power steam-engine and mill, and suppose this estate to be in Jamaica or any other colony where fuel is expensive, and a good steady wind very frequently available. Now in working off a large crop, occupying perhaps five or six months, if every third or fourth day the steam-engine can be spelled by the auxiliary windmill, there will be, out of the five or six, upwards of one full month during which the fuel necessary to work the engine has been saved; and that time is afforded the engineer or negro attendant to examine, clean, or maybe repair, the various parts of the engine. It is no uncommon thing, in many localities in Jamaica, to have a strong sea-breeze almost every day, for a month or more at a time: there are times when the breeze is so very moderate that little power could be obtained from it in mill-work; but it is also equally certain that a very strong breeze frequently prevails, even for many days in succession. It therefore follows that every day which brings with it a good stiff breeze during crop-time, causes a considerable saving to that estate which has, besides its steam-engine, an auxiliary windmill. There cannot be the least difficulty in fixing a horizontal windmill so as to connect and disconnect with the same mill which is driven by the steam-engine; neither can there be any difficulty in connecting and disconnecting, in the same manner, the engine and mill. Improved cane-mills and engines are now sent abroad, which can be thrown in and out of gearing in a moment; and, by the very simplest arrangement, the windmill could be eligibly placed so as to take on itself the work of the engine at any moment the wind might spring up. In cases where bullocks and mules are used for mill-work, of course the force of these arguments is the better established. It must be borne in mind that I am altogether alluding to horizontal, not vertical windmills. In parts of India and the Straits Settlements, the observations I have made on this subject apply; although not to the same extent as in the West Indies, in consequence of the great abundance of fuel in the Straits and in some parts of India.

Cattle-power, as applied to mills, was very common in the West Indies, and no doubt still is. Herds of horned cattle and mules were kept on estates for this and other purposes, entailing a great expense; not only from the loss by death and other circumstances of that kind (noticed at the commencement of Chapter III.), but also from the positive disadvantages of manufacturing by the aid of such power. Entirely disapproving of cattle-power for sugar-mill work, I need not say more on the subject, than that wherever the employment of cattle-mills is persisted in, the planter should be very careful to keep his mill-cattle in good condition: by which I mean that they should have abundance of wholesome dry provender, so as to maintain them in firm hard flesh and good wind; added to which, careful housing and kind treatment should be strictly enforced.

The next and last great motive power is *steam*, which is now in general use throughout the world, where water cannot be made available. Condensing engines appear to have given way almost entirely to those of high pressure: at least, we may with safety say, that where one of the former description is used, three of the latter are employed.

The steam-engine is generally estimated by the horse power it is said to work up to; but to be able definitely to agree as to the power of an engine, it is not only necessary that the diameter of the cylinder be given, but the pressure at which the steam is applied to the cylinder.

The following table, given by Templeton, affords a very good idea of what the diameter of cylinder per horse power requires to be, with steam at different pressures:—

Number of horse-power.	Diameter of Cylinder in inches, with steam at			
	25 lbs. per in.	30 lbs. per in.	40 lbs. per in.	50 lbs. per in.
1	3¾	3½	3	2⅝
2	5¼	4¾	4¼	3¾
3	6½	6	5	4½
4	7½	6¾	6	5¼
6	9	8¼	7¼	6½
8	10½	9¾	8½	7½
10	11¾	11	9½	8¾
Quantity of water in gallons per minute to each horse-power.				
	·45	·50	·61	·73

All engines for propelling sugar-mills, sent to the colonies, should be at least of ten horse power; or we will say of twelve inches diameter of cylinder, at steam twenty-five lbs. per inch: which would be able to work up to about fifteen horse power, with steam at fifty lbs. per inch. None should be under this dimension and power: but it is much more desirable to have an engine of greater power, such as fourteen, sixteen, or eighteen inches diameter would give; so that it can not only drive the sugar-mill, but also perform any other task in addition that may be demanded of it: as working the air and cold water pumps of a vacuum-pan, turning the revolving wheel of Wetzal's concentrating pans, or any other requisite work.

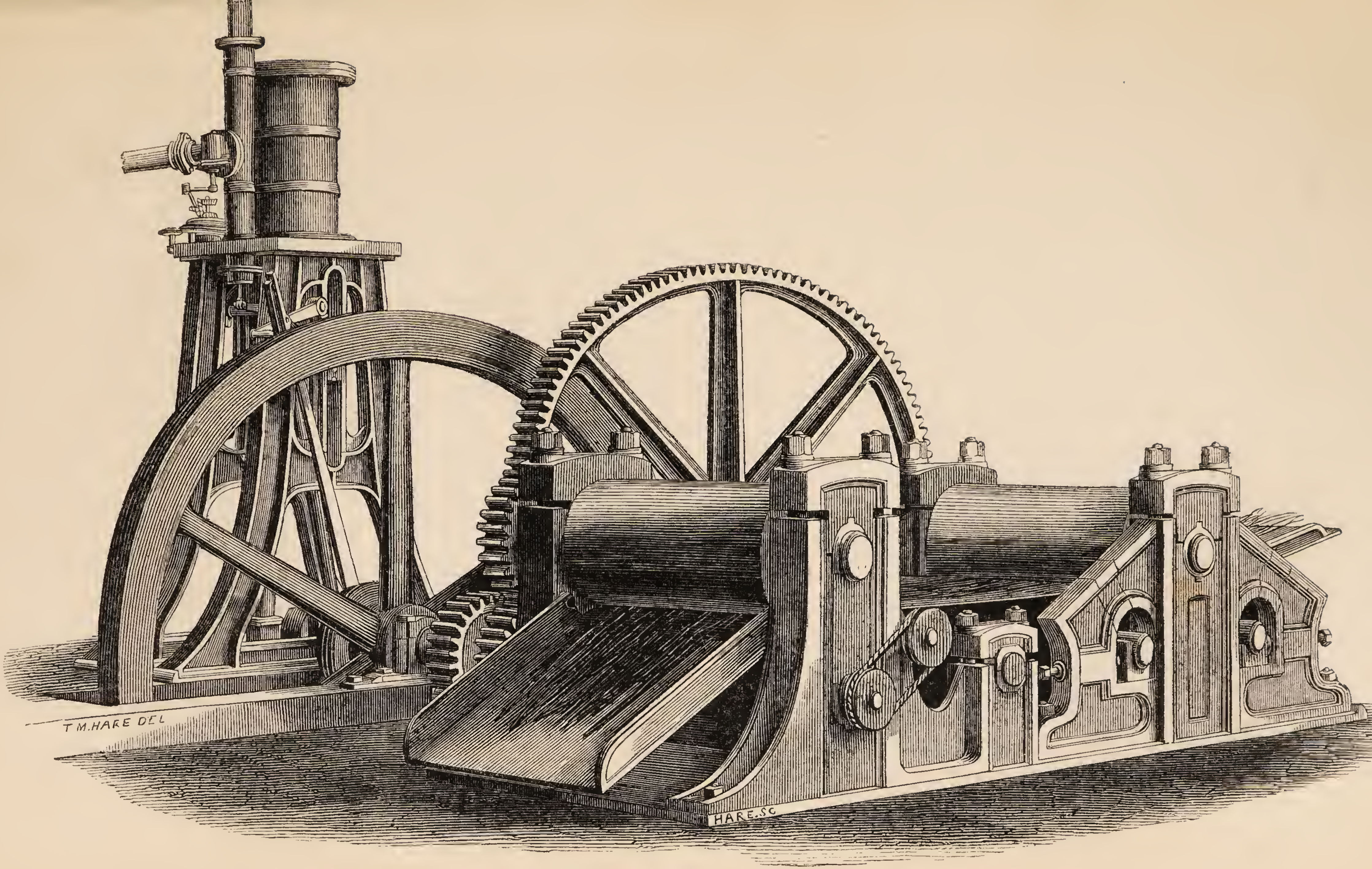
Plate X. represents a steam-engine and sugar-mill with two extra rollers, which are in all respects similar to the machinery recently made and sent to Penang by Messrs. Joseph Woods and Co., of Barge Yard Chambers, Bucklersbury, with the exception of the two extra rollers, which that had not. In this engine, the steam cylinder is eighteen inches diameter, and thirty inches stroke, and it is reckoned of sixteen horse power; although it can with safety be worked up very much higher. The several parts of both engine and mill have had various improvements introduced, with a view to ensure their general strength, endurance, and easy working, as well as to offer facilities for immediate repair in case of breakage.

The pinion on the fly-wheel shaft is 1 foot 9$\frac{7}{8}$ inches diameter, and the wheel on the counter-shaft, attached to and driving the rollers, is 10 feet 6 inches diameter. The rollers will, therefore, make one revolution to 5·76 of the engine, and as this makes 44 per minute, the rollers will make 7·6 revolutions per minute. Being two feet in diameter, the rollers consequently move at the rate of 47·98 feet, superficial velocity, per minute; and the mill is calculated, if it be well supplied with canes, to express sufficient juice to make upwards of six tons of sugar a day: the rollers being four feet in length.

The large wheel is constructed of two frames bolted together, having a smooth circumference, on which cogs are bolted in segmental plates, so that any one or two cogs being broken by accident, a spare segment may be immediately fixed *in situ;* thus ensuring constant repair and efficiency at a very trifling expense. At my especial desire the mill is shown with two extra rollers, for securing the saccharine matter which escapes expression during the passage of the canes through the first set of rollers.

The price at which this engine and sugar-mill (with one set of rollers) is supplied by Messrs. J. Woods and Co., is 1,200*l.*: certainly a moderate sum, considering the power of the engine and the many improvements introduced.

Messrs. Woods and Co. have a large sized model of their engine and mill, the which I have carefully inspected, and am bound to pronounce the whole, as connected, a very excellent piece of machinery. The application of their patent chronometric governors will no doubt tend very



WOODS' STEAM-ENGINE AND SUGAR-MILL.

greatly to the regular and satisfactory working of the engine; which in the sugar colonies is a very desirable object.

The arrangement of the mill with its extra set of rollers or crushing cylinders, is that which is commonly used in Province Wellesley, Mauritius, and Bourbon: with the exception, perhaps, of the band which travels between the first and second set of rollers. A few explanatory remarks may, however, be necessary to show its principle.

The first set comprises the usual number of (three) rollers, one of which has a spur wheel that works into another wheel of similar size on the shaft of the second set of rollers, and communicates the motion which itself receives from the engine. Thus the first set is acted on by the engine, and transmits that power to the second set by means of these spur wheels; so that both sets move on together at the same pace.

The second set comprises only two rollers, which are situated from six to eight feet from the first set; and the expressed cane-stalks, as they issue from the first set, are carried on to the second by means of an endless band which travels between the two sets. At this point, one attendant is posted to direct the passage of the cane-stalks, so that they may be presented to the rollers of the second set in the most desirable manner. Perhaps the best material for the traveller band is brass wire-gauze, not too fine.

During the passage of the expressed stalks between the two sets, a jet of steam, or moderately hot water, may be applied to them if considered desirable: of the two, I should prefer water, as hot as the feeder could bear his hands in; this falling from a very fine rose (placed immediately over the band at a convenient height), would saturate the expressed cane-stalks, whilst the surplus water would descend through the coarse wire-gauze, of which the band is made, into a shallow trough or receiver (immediately under the band), and run off into a gutter, either to waste, or leading into the distil-house. The intended benefit of this application of hot water is two-fold, viz., first in saturating the already expressed cane-stalks, in order to obtain from them during their passage through the second set of rollers, whatever saccharine matter may be still remaining in them; and secondly, in cleansing and keeping perfectly sweet, the traveller band. Wherever the band is used, this continual cleansing operation is a very important point; and I certainly can see nothing against its being generally adopted.

I do not intend to say that either the band or the application of hot water is necessary; yet I cannot but consider that they tend to make the process much more complete and certain. The saturation of the expressed canes with hot water or steam, has the effect of rendering soluble the saccharine matter which may be resident in them in a concrete form, so that when they pass through the second set of rollers, they part with this desirable matter; whereas, if not so saturated, mere pressure, though carried to the greatest possible extent, cannot effect this important object. It has often been proved that canes contain a far larger per centage of crystallizable matter, than planters, even with the best mills, succeed in obtaining from them. This has been pronounced by the most intelligent and skilful chemists to be, in a great degree, owing to the fact of the cane depositing in its cells sugar in a concrete* form; which cannot be obtained by mere pressure, because it is not in solution. Pressure may deprive the cane of its juice, and that juice may contain all the sugar (or crystallizable matter), existing in it in a *soluble* form; but it is evident that whatever portion may have taken a *concrete* form, will remain adhering to the cellular tissue until it is brought into a state of solution, when it may undoubtedly be obtained by a further pressure.

It is also quite clear that this deposit of concrete matter takes place to a much greater extent, in fine, rich, and fully matured canes, than in any others; which assures us of this singular fact, that the more rich and ripe our canes are at the time of cutting (and the more dry the weather has been), the greater is the deposit of saccharine crystallizable matter in a concrete form; and consequently the greater is our *loss*, when means are not used to secure this rich store.

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* Perhaps I should say *crystalline* form, as the microscope discovers true crystals deposited in the cells.

With this great fact before us, it becomes the planter's duty to inquire what means he can employ to prevent such a serious loss to his estate: nothing is more natural and necessary than such a question, and it can be readily and satisfactorily answered. The appliance of a liberal quantum of hot water to the crushed cane, whilst passing along the band from one set of rollers to the other, will be found a simple and sufficiently efficacious means of obtaining the desired object. It entails no expense (worth mentioning) and no labour whatever, and its practice cannot be attended with other than desirable results.

An engine and mill such as represented and described, will grind canes sufficient to yield upwards of 12,000 gallons of juice during the day of from twelve to fourteen hours; besides allowing of the engine performing such work as may be required by the vacuum pan, or Wetzal's concentrators.

The (single set) mills commonly used in the West Indies, very rarely obtain from the canes they crush, more juice than 60 per cent. of their weight; and much more frequently only from 50 to 55 per cent. The mills such as I have represented obtain commonly 70 per cent. of juice, and have been known, where they were carefully adjusted, to yield 75 per cent. Nor do I doubt but that in nine cases out of ten, where these double mills are properly screwed up, their per centage will constantly average 75 or even more. The cost of such a mill, with rollers four feet in length and two feet in diameter,. with all improvements, is about 600*l.* as nearly as can be; whereas the single set costs from 400*l.* to 450*l.*

The extra power necessary to work them is very inconsiderable, and together with the cost of the extra rollers, can form but a very inconsiderable item in comparison with the very large per centage secured by their means. I have no hesitation in saying, that the cost of an engine and mill such as represented by Plate X. does not exceed 1,400*l*. whilst it must be borne in mind that the engine, independently of driving the mill, has besides, a spare power sufficient to work a vacuum pan, and Wetzal's concentrators (very probably six), or to pump water for irrigation, &c. In stating this sum, many whose finances are at a low ebb, will say I have mentioned a price which places it beyond their reach; and so unfortunately it may be: but I am informing the whole planting community of the best and most suitable machinery for carrying out sugar operations; and although the first cost may appear high to the half ruined planter, yet to those who possess capital, it will be evident that the truest economy is to have really good and efficient machinery, instead of cheap, make-shift apparatus. There are, no doubt, a very great number of excellent steam engines in London, and various parts of Great Britain, which have been put aside; perhaps from not being sufficiently powerful for some particular description of work, or from failures, or from mere whim, or from a thousand different causes constantly operating: such engines might be obtained at one-half their first cost. Those, however, are chances which can scarcely be expected to meet recommendation in this work.

In the working of a sugar-mill great care should be taken in adjusting the rollers in the best possible position to carry out the object in view with the least possible unnecessary strain. We all know that the cane (not the native cane of India) varies in size from 1 inch, to 2½ inches in diameter: say 1¾ inch on an average; it therefore seems only reasonable that the rollers destined to receive the cane from the feeding board, and give it its first crushing, should have a moderately wide space allowed between them; for we require them to break down the cane, so that the next pressure it receives may deprive it of its juice, and fit it to undergo saturation previous to its being submitted to a third and final pressure. I consequently recommend the first under roller to be adjusted exactly five-sixteenths of an inch from the main or upper roller; and the second under roller just one-tenth of an inch from the upper roller. Having passed through the first set, and received a saturation with hot water, the cane comes next to the second set of two rollers, which should be set so close that nothing thicker than a sheet of writing paper may pass through uncrushed; in which case the whole of the liquid contents of the cane are expressed, and the cane-trash leaves the mill comparatively quite dry. This trash may be much crushed and broken up; but that should be no objection: especially as all cane-trash should be used as manure.

Great care should be observed in feeding the mill that the canes are put in evenly and not suffered to overlap each other; and very great regularity should be exhibited in the quantity of canes supplied to the mill, always keeping as nearly as possible a similar number, well arranged along its length, passing through together; by which means the working of the engine will be uniform, and that of the mill quite smooth.

The clarifiers, as shown in Plate VIII, are of 500 gallons, with precipitators of the same dimensions, worked by open fires, as mentioned at page 287; whilst in Plate IX. these vessels are of the same size, but are heated by *steam:* they are supposed to be made of sheet iron, and are set, the clarifiers elevated above the precipitators, and the latter above the ranges of boilers, so that the cane-juice descends from one to the other in succession. They are all flat-bottomed, and are each provided with cocks through which to draw down the juice.

The boiler ranges as shown in Plate VIII., consist of five pans each, all made of sheet iron, and having flat or very slightly convex (inside) bottoms; each division being provided with a slide valve, to pass the liquor from one pan to the other, whilst the tache has a large discharge valve to skip the syrup, when it is sufficiently boiled. The Wetzal pan is a very simple yet efficacious apparatus for concentrating syrup after it leaves the boiler range; it has a steam jacke and inside piping, into which steam is admitted,* at the same time that a revolving roller or wheel is set in motion by being connected with the steam engine by means of a band passing over its drum. This roller or wheel is made by having two circular pieces of wood (of about three feet in diameter,) through the centre of which an iron or hardwood shaft runs; these pieces fixed on the shaft at about six feet apart, form the ends of the wheel, whilst long pieces of wood of about three-fourths of an inch in diameter and round, run across from one circular end piece to the other, at about four or six inches apart. The wheel being thus made is fitted into the pan, and its shaft rests on bearings, by means of which it readily revolves; at one end of the shaft a drum-wheel is fixed, over which the band from the engine works and communicates a rotary motion to the machine. Thus when working, the syrup is drawn into the pan, steam is turned on to heat it, the drum wheel is thrown into gearing, and the roller or wheel rotates; one-third of its diameter, or more, being immersed in the syrup, which in revolving it consequently agitates, and exposes to the air. They are altogether so simple that they are made on the estates in Province Wellesley, in which settlement they are very generally used.†

Plate IX., comprising a representation of the peculiar system of boiling wholly by steam, requires to be more minutely illustrated to admit of a desirable explanation of the principles involved. But before I enter on this subject, it will be preferable to treat of those improved evaporators worked by open fires.

I need not trouble the planter with a mention of the old-

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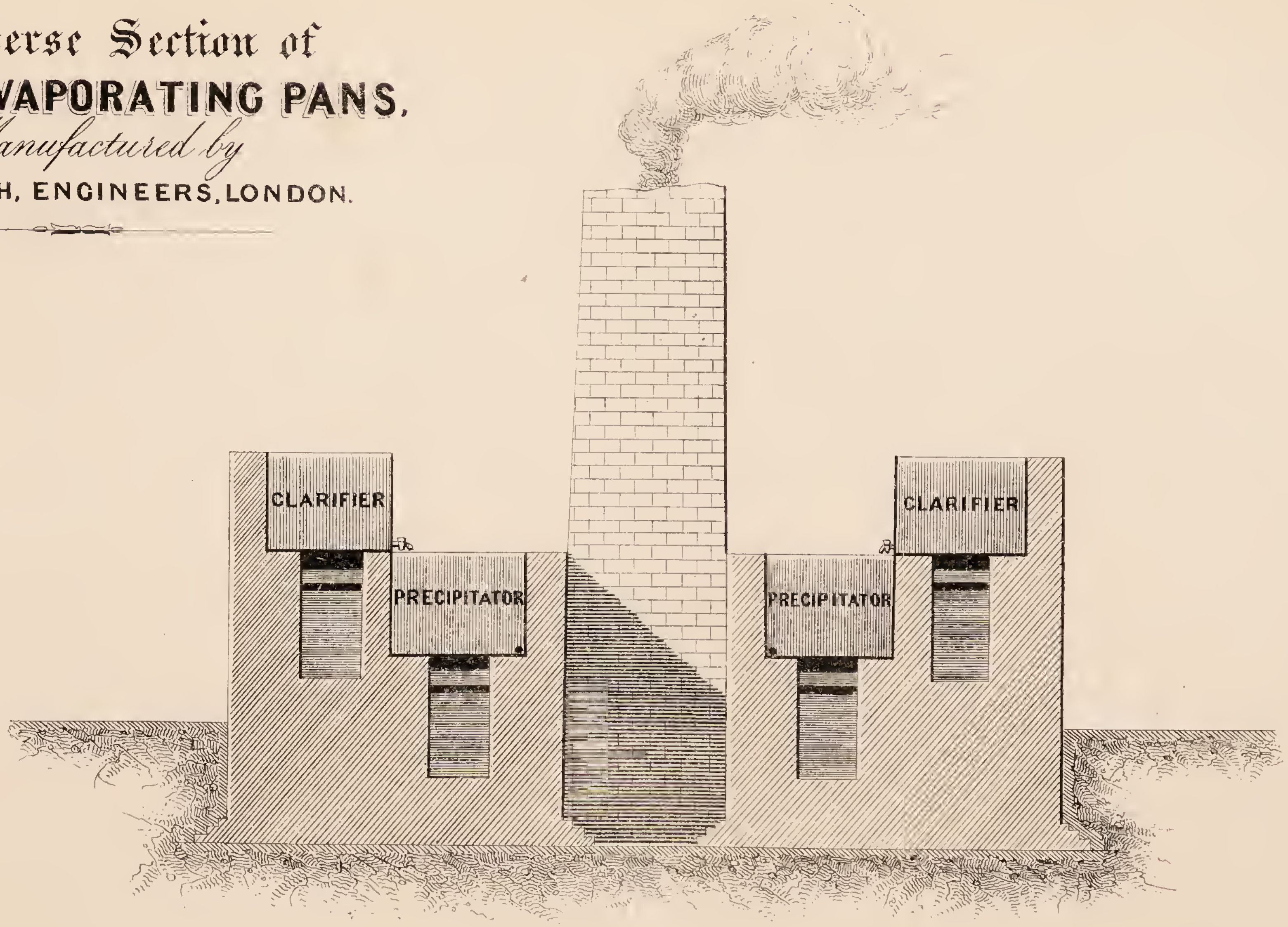
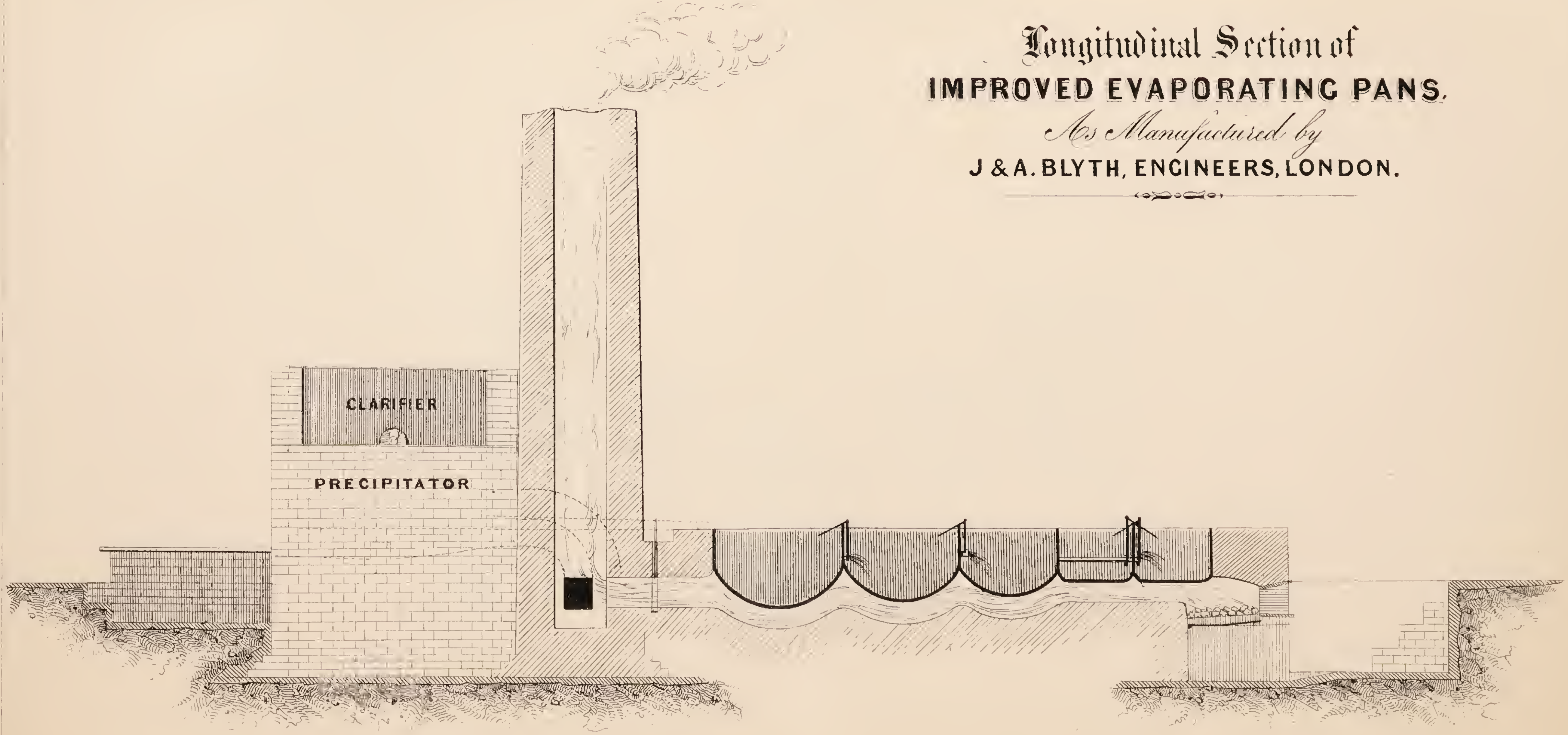
* In Province Wellesley, the escape steam from the engine suffices to work these pans.

† This concentrating apparatus was introduced into Province Wellesley in the early part of 1845, by M. Donadieu, who received drawings of it from Bourbon; where, as I understood, it was first invented by M. Wetzal, a French chemist, and had been in use in that island for one or two years. As I said before, I cannot state whether M. Wetzal or Mr. Gadesden is the real inventor.

Transverse Section of
IMPROVED EVAPORATING PANS,
As Manufactured by
J & A. BLYTH, ENGINEERS, LONDON.



Litho Waterlow & Sons, 66 London Wall



Longitudinal Section of IMPROVED EVAPORATING PANS.

As Manufactured by

J & A. BLYTH, ENGINEERS, LONDON.

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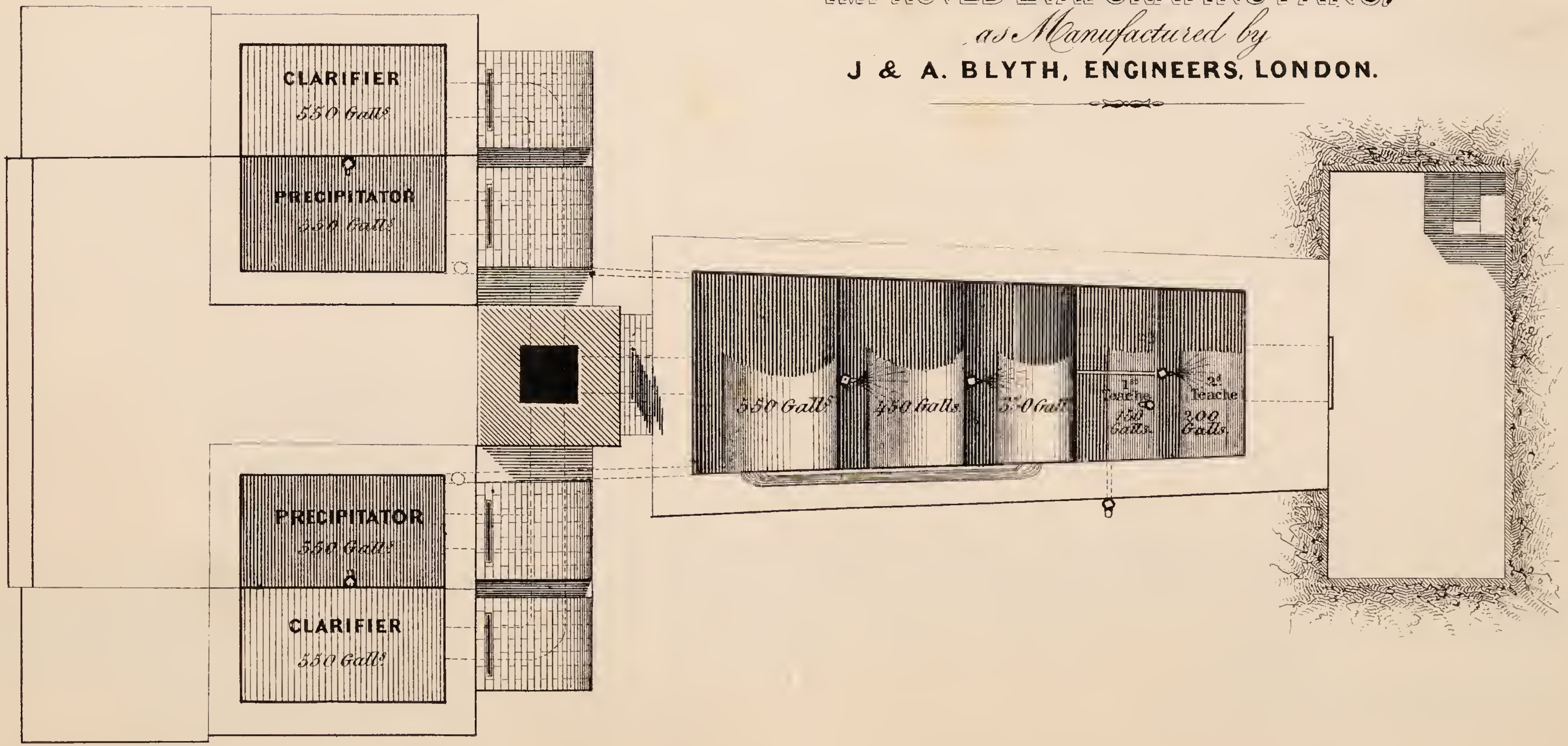
Plan of
IMPROVED EVAPORATING PANS,
as Manufactured by
J & A. BLYTH, ENGINEERS, LONDON.



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time, and fortunately bygone, boilers so common but a few years ago: it is scarcely possible that any one can still persist in their use; therefore it is quite irrelevant to speak of them.

Plate XI. is a plan of Messrs. Blyth's improved evaporating pans, which are very similar to the range known in Province Wellesley, the Mauritius, and Bourbon, as "Gimart's Batterie;" the difference being that the latter has no precipitators or second defecators (which is a very serious fault in "Gimart's Batterie)," and that the former are connected sideways instead of endways, as in the latter.

Plate XII. gives a longitudinal section of the same pans; and Plate XIII. affords an end view, showing the elevation of the clarifiers and precipitators. In this range, the clarifiers, precipitators and first evaporator, contain each 550 gallons; the second evaporator 450 gallons; the third, 350 gallons; the second tache 200 gallons, and the tache 150 gallons. They are all made either of copper or sheet iron, and have valves communicating from one pan to the other: but in the tache the peculiarity is observant of placing it in the fourth position instead of the fifth, which causes the communication pipe from the third pan to cross the tache, in order to discharge its contents into the second tache. The reason for this arrangement of the tache is, that the great draft of the fire causes the flame and heat to strike more powerfully on the bottom of the pan occupying the fourth position than on any other; which has induced the change of place between the tache and second tache.

As I have before remarked, this boiler range is in general use, and gives very great satisfaction indeed. The fact of Messrs. Blyth's plan including the second defecators, termed precipitators, gives it a great advantage over that of Gimart: this will be more particularly discussed as we proceed. However, in other respects, the two plans are much the same, and no doubt can be entertained as to their excellent working; for my own part I can unhesitatingly say, that, as evaporators, they perform their duty exceedingly well, and always give satisfaction.

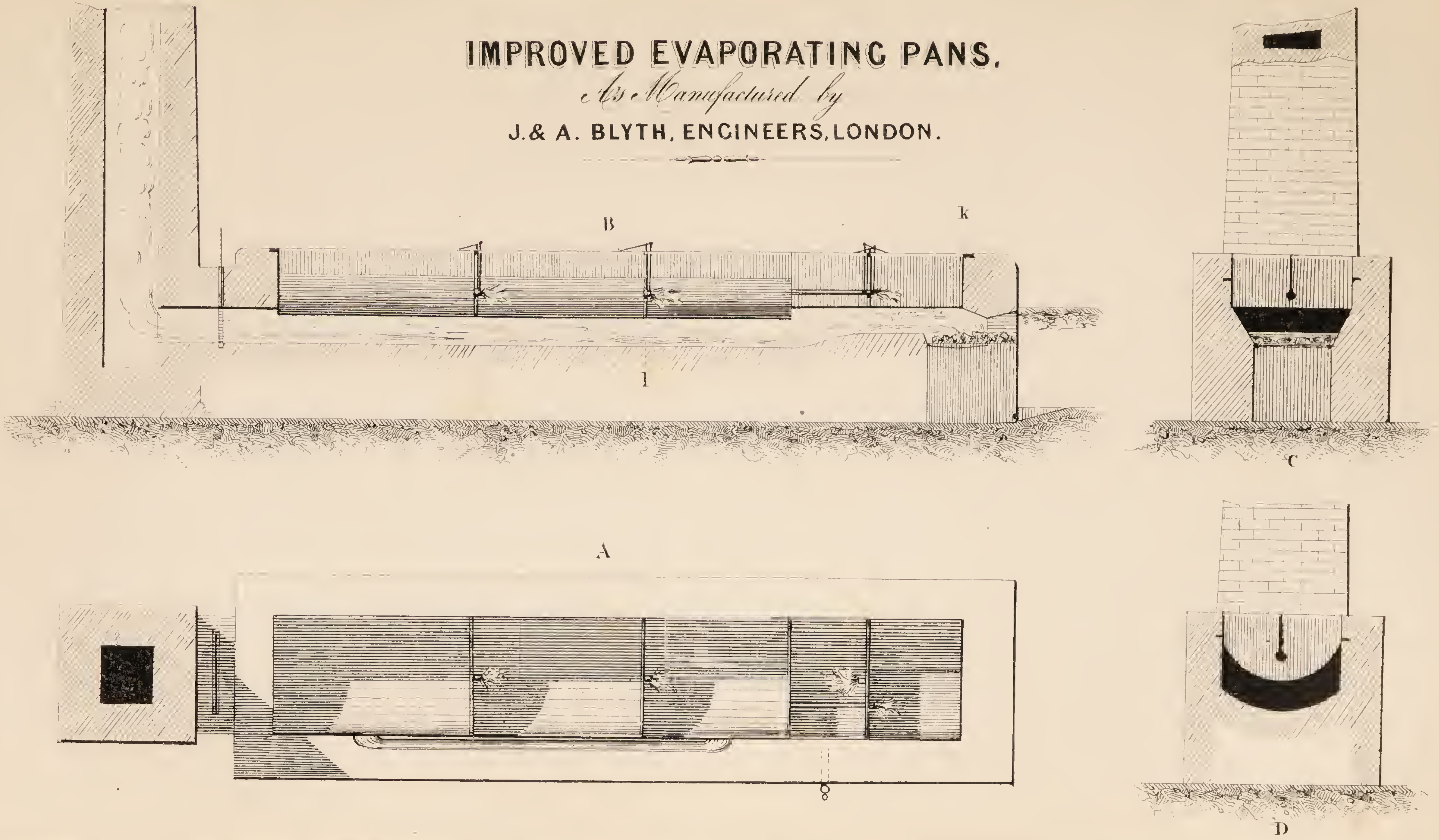
The range is excellently well adapted for boiling down the liquor to that density which fits it for transmission to the vacuum pan, or Wetzal's concentrator; although, if it be desired, of course the syrup can be at once concentrated in the tache. Messrs. Blyth's plan, however, embraces the use of the vacuum pan, or Wetzal's pan; but neither have been shown in the engravings, as their employment is an understood circumstance. The five evaporators together contain 1,700 gallons of juice, and as they boil very fast, one range, as represented, would suffice for a small estate; whereas, on a large property, it would only be necessary to add another range. The two ranges would then occupy positions similar to those shown in Plate VIII. I have not heard the price at which such a single range of evaporators, with two clarifiers and two precipitators complete, can be manufactured at; but, judging from my own experience in these matters, I should imagine that if made of good wrought (sheet) iron with proper valves, they would not cost more than from 200*l.* to 250*l.*

Another variety of these pans, as manufactured by the Messrs. Blyth, is represented in Plate XIV. and is considered by many planters in the Mauritius, Bourbon, and Province Wellesley, as being preferable to that in Plates XI. and XII. Figure A, Plate XIV., is a (bird's-eye view) plan, showing the length and breadth of the pans; B is the longitudinal section; C is the cross section at *k*, showing the flat-bottomed form of the second tache; whilst D is the cross section at *l*, showing the round-bottomed form of the three evaporators. It will be seen that these pans, unlike the former, are connected lengthways, instead of sideways: by this arrangement, the boilermen have less difficulty in cleaning the liquor; the flue is narrower and longer; and consequently the flame and heated air have a greater length to traverse before they reach the chimney. The communication between the pans, is by means of slide valves, worked by small levers; and in this plan, as in the former, the tache is the second from the furnace. Both taches are flat-bottomed,

IMPROVED EVAPORATING PANS.

As Manufactured by

J. & A. BLYTH, ENGINEERS, LONDON.



Litho. Waterlow & Sons, 66, London Wall

whilst the three evaporators are round; as shown in cross section D.*

This particular kind of batterie is in especial favour in the colonies I have named; and, on the whole, I prefer it myself to any other that I have ever seen: this I can state of them, after more than eighteen months' observation of their performance. All the sets that I have seen are of sheet or plate iron, of about one-fifth of an inch thick; and the ledges to afford boiling room, which are not shown in either plate, are made of very thin sheet iron, bent to the desired angle. These ledges are generally riveted to the pans in the colony, as they otherwise are liable to be broken off during their passage from England.

The clarifiers and precipitators are of course placed similarly in both varieties of batteries, although they are not shown in the Plate XIV.†

I have every possible reason to speak well of these evaporating pans, from the excellent work which I have known them to perform, and I am sure that the testimony of every planter who has used them will bear me out in all I can say in their favour; but, whilst I am bound to accord them commendation in proportion to their merits, it is imperatively necessary to state my conviction that the pans best suited to the boiling of sugar, if over a naked fire, are shallow pans with their bottoms slightly convex inside.

In these several plans, it being understood that wood or coal is to be used (instead of cane-trash), the furnaces would, of course, be made to suit the most economical consumption of such description of fuel.

Recently, however, the desire is becoming extremely strong to boil the cane-liquor entirely by steam, instead of over naked fires; planters are beginning to perceive the

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* This plan is identical with Gimart's.

† These pans cost, each *range*, of five iron pans = 1,500 gallons,	£100	0	0
Four Defecators containing 500 gallons, each £30,............	120	0	0
including all fittings, &c. and packed ready for exportation.			
Total,	£220	0	0

advantage of evaporating their cane-liquor, without running the risk of burning it as it passes through the boiling pans.

I have seen drawings of evaporators so heated, which are at this moment being worked with great success in Bourbon and Java; and the accounts that I have received of their perfect adaptation to the requirements of the sugar-planter, entirely coincide with the views I have long entertained on the subject.

Plate XV. represents a range of six evaporating pans, made of wrought iron (plate or sheet iron) and worked by steam. In figure 1, *a a* are the six pans, containing each a copper worm of three inches diameter, and having each a double bottom; *b* is the steam-main, through which the steam is supplied to the pans; *c* is the condensed water-pipe from the bottom of the pans; *d d* the valves for letting on or shutting off steam to the worms; *e e* the valves for letting off the condensed water from the double bottoms; *f f* are the sluice-valves connecting the pans with one another; *g g* (in figure 2) the handles for raising the sluice-valves by screw rods; *h* the condensed water cistern; *j* the pipe for carrying off the condensed water from cistern, and *k* the valve for discharging the syrup from the last evaporator or tache. These pans contain each 450 gallons of cane-liquor, and are worked as follows; the steam being let into the main *b* from the boilers, is let into the worms of the six pans by opening the valves *d* (so that either pan can have the steam let into its worm, or shut off, without in any way interfering with the other pans), and passing through the worm, enters the double bottom of the pan, from whence it is discharged, as condensed water, through the escape-valve *e*, on the condensed water-main *c*. The copper worms are so fitted that they can be turned up and cleaned whenever required, which is managed by the two ends of the worm working in stuffing-boxes or swivel joints.

The great advantage of these steam pans is; first, that the quantity of steam, and its pressure, can be nicely regulated by means of the valves *d* and *e*, so that not the smallest

PLATE XV.

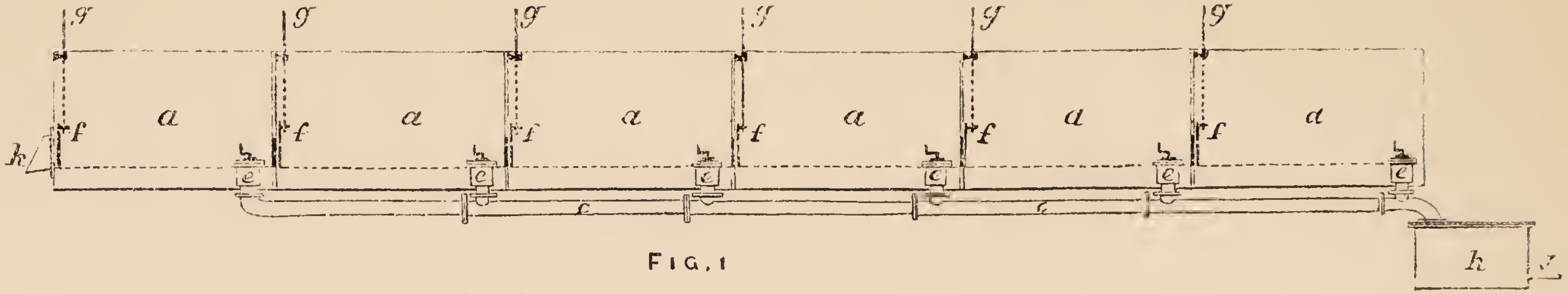


FIG. 1

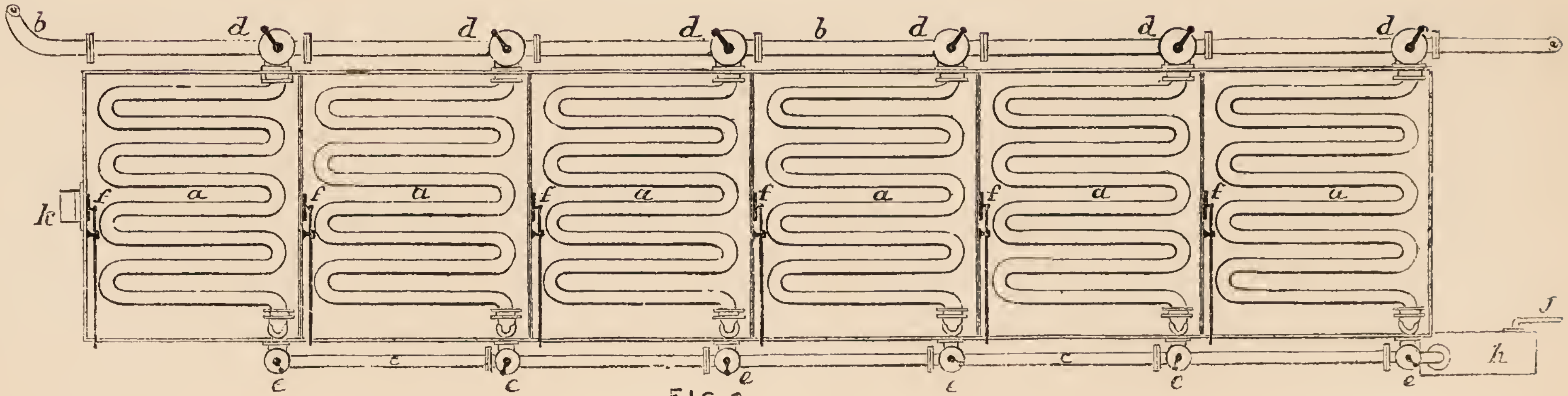


FIG. 2

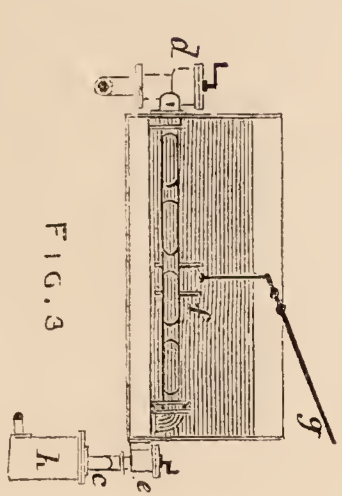
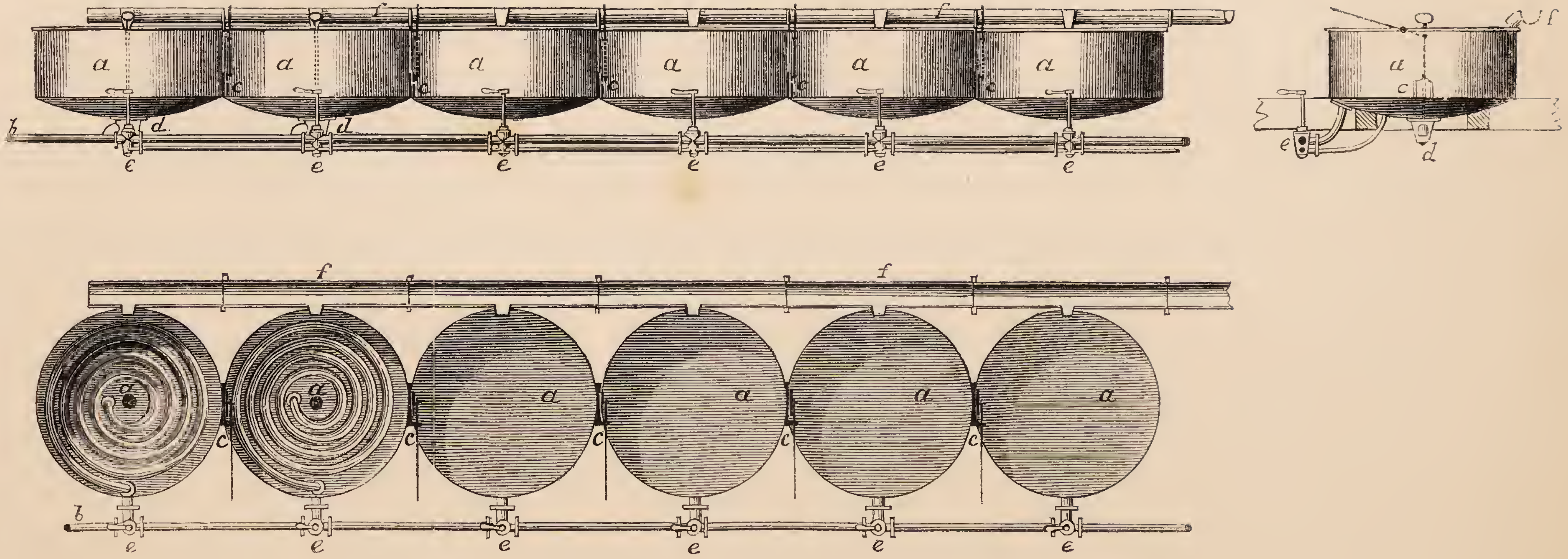


FIG. 3

PLAN OF IMPROVED STEAM EVAPORATORS (IRON), AS MANUFACTURED BY JAMES SHEARS AND SONS, LONDON.

PLATE XVI.



PLAN OF IMPROVED STEAM EVAPORATORS (COPPER), AS MANUFACTURED BY JAMES SHEARS AND SONS, LONDON.

fear need be entertained as to the liability of the liquor or syrup to burn, which in other cases may arise from steam kept at a great pressure; secondly, any or every pan may be used without interfering with each other, steam being let on or shut off without affecting the working of the others: thus, if the syrup is to be concentrated in the tache, the valve *d* is opened as wide as possible, to throw in a large amount of steam, whilst the valve *e* is so adjusted as to keep the pressure up to a certain degree, and directly the point of concentration is arrived at, the valve *d* is closed and *e* opened wide, until the skip is struck. There is also a skimmings gutter appertaining to the range, but which is not shown; the engraving being intended more to convey a correct idea of the steam apparatus.

This steam battery is that which is supposed to occupy a place in the improved plan of manufactory, Plate IX.

The next range is Shears' copper steam-heated evaporators, comprising seven pans made of copper, with cast iron steam jackets, and containing each a coil of copper piping. Plate XVI. represents a plan (bird's-eye view), a longitudinal section, and a cross section of these evaporators.

a a, are seven copper pans with cast iron steam cases or bottoms.
b b, a couple of pipes running in front of the pans for supplying steam, and carrying off the condensed water, by means of a cock with six outlets or ways.
c the sluice valves connecting the pans for the purpose of drawing down liquor from one pan to the other.
d, two cocks for discharging the syrup when sufficiently concentrated.
e, cocks with six ways or outlets by means of which the steam may be admitted, and the condensed water carried off at the same time, to and from any one pan in the set.
f, is a gutter for conveying clarified cane-liquor to the pans.

These copper pans have been supplied by Messrs. Shears and Sons to many planters of the East, and in all cases they have given very great satisfaction. In the plan represented, the cane-liquor is supposed to run from the precipitators, along the gutter *f*, into either of the pans; but it would very rarely happen that such liquor ran into other than the first or second evaporators, except in commencing work; for the liquor, as it is cleaned and boils down, is drawn into the other pans successively through the sluice valves *c*.

When working, a moveable gutter is placed over the first, second, and third evaporators, for the purpose of conveying away the scum that is skimmed off; although it is to be expected that, by adopting proper measures, a very small portion of scum would rise in the evaporating pans. I had an opportunity of seeing, at the manufactory of Messrs. Shears and Sons, some of these copper steam pans, which they were making to send abroad, where they were to be used as defecators; consequently there was a slight difference in respect to the sluice valves and other trifling matters, which, of course, as defecators they did not require.

I had very great pleasure in remarking the excellent workmanship bestowed on them; which to a planter, who so often suffers from bad work, is a matter of particular importance. Boiling cane-juice by steam is, in my opinion, the very best, and in the end far cheapest, method the planter can adopt; wherever there is abundance of fuel, of course the expediency becomes still more strong. I am, however, aware that many planters will be quite aghast at the bare idea of incurring the expense necessary to establish a proper boiling range worked by steam, on an estate: but it must be borne in mind that it is incumbent on me to point out to the planting community the best means of manufacturing their produce, leaving it naturally to themselves to determine to what extent their means will warrant them in going. The pans in Plate XV. are capable of yielding syrup for six tons of sugar in twelve hours boiling, and therefore fully competent to take off a crop of from 500 to 750 tons of sugar; now, as a matter for reflection, I will suppose an estate making 500 tons with the common pans hung over a naked fire, then allow (as we very safely may) that by means of the steam pans an increased return is secured of 3 per cent. = 15 tons on the whole crop, and that the quality is so much improved as to sell in the British market at 2*s.* per cwt. higher than before; the account would then stand thus:—

15 tons = 300 cwts. of sugar (increased produce) at 12*s.*	£180	0
500 tons = 10,000 cwts. ditto, improved in quality, 2*s.* per cwt.	1000	0
	£1180	0

I think the increased quantity and quality are only stated here at about one-half what would really result; but at the very low rate of improvement calculated for in this account, we find a sum accruing more than sufficient to pay for the steam pans and steam boilers complete :[*] of course, not including the defecators or vacuum pan; for to effect the improvement reckoned on, the steam evaporators might manage to accomplish the concentrating operation without the aid of a vacuum pan, merely by having a moveable wheel (similar to Wetzal's) fitted to the last pan or concentrating tache, so that it could be moved away when not required. This wheel, worked by a band from the engine, together with a boarding to keep off the steam from the other pans, would be all that is necessary. No capitalist in settling a fine estate of 500 tons, would, however, be doing justice to the property, were he to neglect furnishing the manufactory with the machinery best calculated to produce the largest amount of sugar at the cheapest rate. It is only the planter whose necessities are great, who will content himself with make-shift contrivances to arrive at a desired result.

The great body of planters, whose affairs are unhappily in a state of embarrassment, cannot, I am well aware, provide funds sufficient to purchase expensive steam machinery; but I do not see any expenditure that may not reasonably be incurred, even by the most necessitous planter, attendant on the purchase of Blyth's improved pans, or evaporators of similar character. It has been too much the custom to view other than copper pans as unsuitable in sugar manufacture;

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[*] The cost of one such range of evaporators (plate 15) containing 2,700 gallons of liquor, together with two large steam boilers of improved construction, would be about 950*l.*, capable of turning out six tons of sugar a day.

and the consequence is, that when an improved form of pan is suggested to the Jamaica planter, he immediately conjures up in his imagination, a magnificent set of copper pans, costing a sum of money very far beyond his means.

But this need not be; my own experience during the last seven years has shown me, that sugar can be produced in iron pans as good as that from those of copper. Copper is a better conductor of heat than iron, and it may possibly happen that iron, as a metal, affects the juice at times; but I cannot say that I think any great injury can arise from the latter cause, or much loss of fuel from the former.

The clarifier or precipitator (whichever it may be) wherein reagents, such as sulphuric acid, sulphate of alumina, &c. &c. are used for the ultimate clarification of the juice, if made of iron, is liable to impart to the juice a metallic taint, as the iron becomes oxidized: but it appears equally certain that such reagents also oxidize copper; the point therefore is, to choose between the two oxides; and here it seems that the oxide of iron is the more injurious, inasmuch as it attracts moisture from the atmosphere, and consequently causes a deliquescence in the sugar, when it exists to any extent. It would therefore be expedient to have at least one copper precipitator in which these reagents could be used, if considered desirable. The planter who can afford it will, on the other hand, have all his precipitators of copper, if not his clarifiers and boiler ranges. In fact, the question whether really superior machinery or that of an inferior class shall be used, is altogether one of pounds, shillings, and pence, which the position of the planter must decide.

The judicious hanging of the boilers or evaporating pans, is a subject of such great importance, that I must particularly direct the attention of the planter to this great means of economizing his fuel. A range of evaporators badly hung will frequently consume as much fuel as two ranges that are well hung, and yet not do so much or such good work as either of the latter. In Jamaica, the chimney flues are usually very much too small; of which fact many planters have of late years been convinced; consequently many estates have not only had their coppers re-hung, but their chimneys rebuilt.

In these cases, the improvement in their working and the economy of fuel has been so great, that the managers of the estates have expressed themselves quite delighted. In respect to machinery, well hung boilers, and large chimneys, Demerara seems to have set the example; an example which many of the islands are, I understand, following. In hanging boilers (evaporators), a very great object is to secure the admission of a supply of air about the second tache, or the third boiler; as by this means the combustion of the fuel is rendered complete, and little or no smoke is seen to issue from the chimney.

A wedge-like slit or opening in the wall accomplishes this end very desirably, *id est*, a slit in the wall (between the first and second tache) of about eight inches high, half an inch wide (next the flue), and opening outwards to fifteen inches wide.

In this opening, a loose brick may be placed so as to regulate the admission of air. The first time I saw this plan in operation was in the upper part of India, when visiting a native kerkhanna (refinery) on a large scale. The fire was large, and burning fiercely, but I saw no smoke coming from the very low chimney; so I inquired how it happened that the wood burned so brightly and well, and no smoke came from the chimney, when the native immediately pointed out to me two small openings (as I have described), which admitted air into the midst of the burning mass, and effected the complete combustion of the fuel, without producing any smoke.

To test the effect of these air holes, I had fresh wood added, which occasioned the smallest possible amount of smoke to issue from the chimney. I then stopped up the air holes, when the smoke rose in dense volumes!

During some days that I remained in the neighbourhood, I tried the same experiment, and many others of a similar character, but always with the same result. I found, on inquiry, that it was a very ancient custom, and much practised by the Nepaulese. I never saw it in India but three times, for the native kerkhannas very seldom have any chimnies to their furnaces; but what I did see was so entirely convincing, that I should never think of erecting (hanging) evaporators, or boilers of any description, without having them provided with similar inlets for a supply of air to aid combustion.

In hanging the clarifiers, they should be so placed that the heated air from the evaporating range may pass under them when they require to be heated, or up the chimney direct when not required. For instance; a main flue runs in front of the clarifiers, with appropriate dampers, to admit the heated air, &c. under either of the clarifiers, as may be necessary, or, when not wanted for the clarifiers, then to the chimney direct.

The only inconvenience in this mode that I know of is, that at times the fire may be so powerful that the contents of the clarifier may be heated to a greater degree than is desirable; but this can only arise from the gross neglect of the attendant, as the damper of the flue leading direct to the chimney being but very slightly opened, would immediately lessen the heat. There should be an opening under each clarifier, for the purpose of making a fire to heat its contents previous to fire being "called" to the evaporating ranges. I do not mean that grating bars need be placed under the clarifiers, for I believe that there is no necessity whatever for them, as a sufficient fire can be obtained without; for it must be remembered that the lower the temperature at which the juice can be made to throw up its scum, the better: at all events it never should reach the boiling point.

If there is any part of the operation in which the employment of a few handfuls of cane-trash for fuel may be sanctioned, it is in heating two or three clarifiers of juice at the commencement, to start the ranges. But it must be observed, that I have seen numerous cases of wood being used under far more disadvantageous circumstances, and yet burning brightly and well.

The precipitators should always have fire places and grating bars of their own, quite distinct from the clarifiers and evaporators; so that there may be no connection whatever with the flues of the latter.

In connection with the precipitators, I shall have occasion to speak of cisterns for fining the cane liquor; I therefore may mention that there is no necessity to make them of metal, as good wood will answer perfectly well—the only precaution requisite being to wash them well, and then rinse them down with lime water, which will serve to keep them quite sweet.

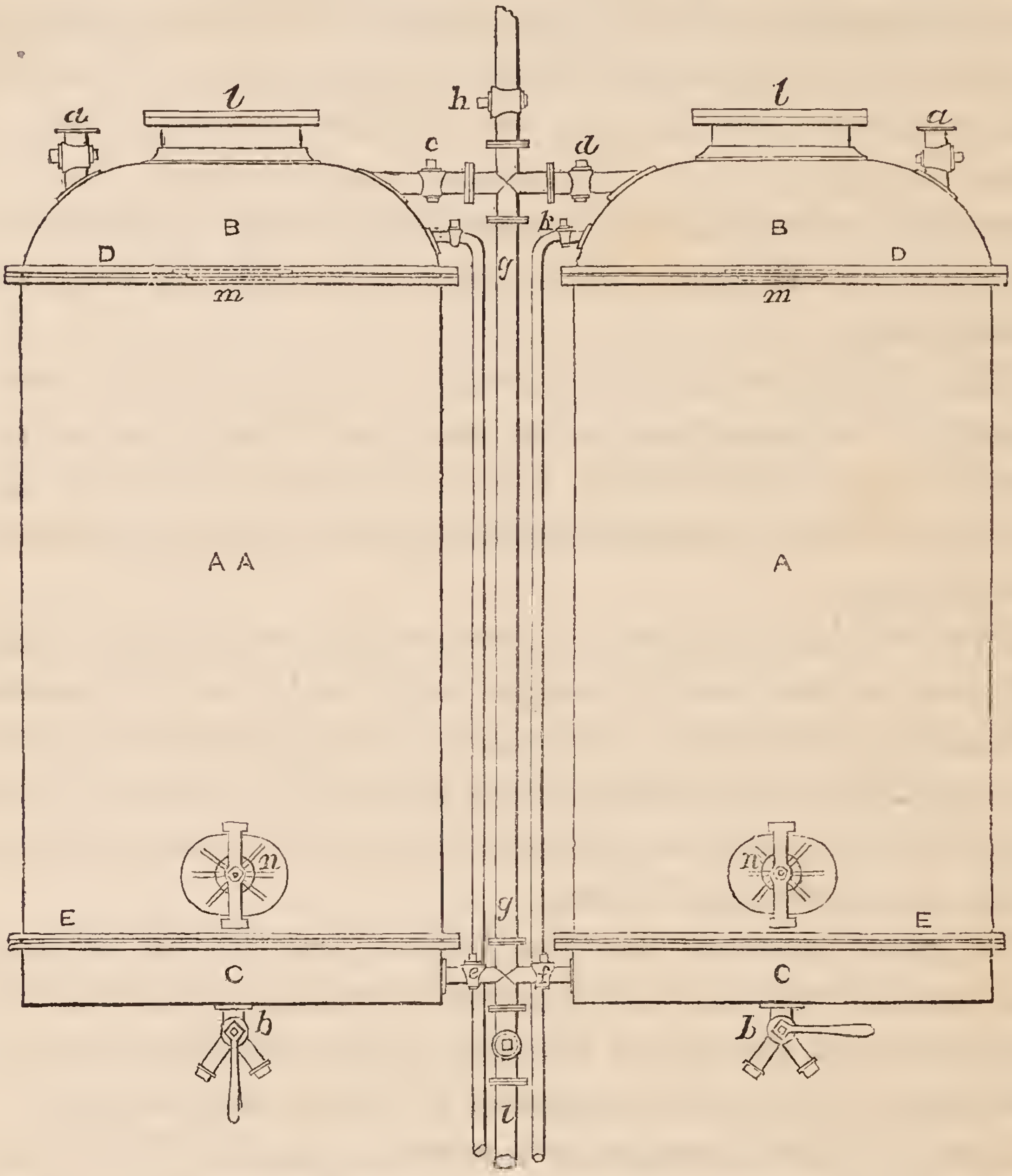
After the liquor is boiled down to a syrup of the desired density, it is passed on to the charcoal filters in order to be decolorized. These filters are of various kinds, and many of them discover a considerable degree of ingenuity in their construction.

Thus we have Peyron's filters, which are air-tight copper cylinders of six feet in height and three feet in diameter, with double bottoms to each; they are ranged three together, the pipe of the first leading from its double bottom up to the top of the second; the pipe of which, in like manner, leads to the top of the third filter.

The space between the false bottom and the top of each is well packed with animal charcoal, in grains; and the syrup, being let in at the top of the first, passes through the three filters, and is let off by means of a cock in the last one.

Dumont's filter consists of a wooden vessel or box of about three feet square at the top, two feet at the bottom, and about three and a half to four feet deep. It has a double bottom, or rather a perforated false bottom, with a piece of flannel spread on it, over which is laid, very evenly, the granular animal charcoal, previously moistened with water, until about two-thirds of the box is filled. Another piece of flannel then covers the charcoal, over which is laid a piece of wire gauze. Communicating with the space between the bottoms is a small tube, or air pipe, to let the air escape into the atmosphere. When the syrup has passed through the body of the charcoal, it is drawn off by a cock which is fitted into the vessel below the false bottom. This seems to me to be a simple and very excellent filter.

The next is the improved animal charcoal filter, by Shears and Sons, of Bankside, London.



Shears's Improved Charcoal Filters.

The above represents two copper cylindrical vessels, connected with each other so that they can be worked either separately or together. The syrup is let into the upper chamber B, by the cock *a*, from which it passes through the body of the charcoal contained in the large chamber A, into the lower chamber C; and is discharged, purified, by the cock *b*, into an appropriate gutter.

But if the two filters are required to be used together, the discharge cock of the first filter must be shut, and its cock *e* must be opened; the syrup, which has then passed through the first filter, say A A, will consequently rise through the pipe *g g* into the upper chamber B of the second filter, the cock *d* being also opened to admit it, and passing through the charcoal, as in the first filter, will be let off by the discharge cock *b*.

Either filter can be made the *first* in the operation, as it suits convenience, for they both are similarly provided.

Every part of the filter can be washed out and completely cleansed by means of hot water or steam admitted through the cock *h*, which is connected with the pipe *g*, and commands by the cocks *c*, *d*, *e*, *f*, all parts of the apparatus; the cock *k* carrying off the dirty water, &c. from the upper chamber B; and the discharge cock *b*, from the lower chamber C.

The cock *k* may at times be used as a foul air-cock; but there are small air-cocks for this especial purpose, both in the upper and lower chambers. All accumulations of dirt can be cleaned out through the several man-holes; and the charcoal taken out and replaced by the same means. These filters can be purified by the searching power of steam, let in through the cock *i*, which must be connected with a pipe from the steam boiler.

There can be no doubt as to the efficiency of these improved filters, and the easy manner in which they can be worked; but their expense as a first cost I am inclined to think will operate against them.

The peculiar property that animal charcoal has, in decolouring and otherwise purifying syrups, is of so complicated and extraordinary a character, that anything like a clear explanation has never yet been given as to the particular causes which influence its action. Amongst the best accounts we have, is that contained in the prize essay of M. Payen, wherein he states, 1. That the decolouring power of charcoal depends in general upon its state of division; 2. That in the various charcoals, the carbonaceous matter acts only upon the colouring matters, combining with and precipitating them; 3. That in the application of charcoal to the refining of sugar, it acts also upon the gluten, for it singularly promotes crystallization; 4. That according to the above principles, the decolouring action of charcoals may be so modified as to make the most inert become the most active; 5. That the distinction between animal and vegetable charcoals is improper, and that we may substitute for it that of dull and brilliant charcoals; 6. That of the substances present in charcoal besides carbon, and particularly animal charcoal, those which favour the decolouring action have an influence relative only to the carbon; they serve as auxiliaries to it by insulating its particles, and presenting them more freely to the action of the colouring matter; 7. That animal charcoal, besides its decolouring power, has the valuable property of taking lime in solution from water and syrup; 8. That neither vegetable nor other charcoals, besides animal, have this power of abstracting lime; 9. That by the aid of the decolorimeter, or graduated tube, charged with a test solution of indigo or molasses, it is easy to appreciate exactly the decolouring properties of all kinds of charcoal.

It has long been a matter of surprise with me that planters do not avail themselves of the highly valuable properties of charcoal, and thereby render their sugar of a first-rate quality, instead of sending to Europe the very inferior sugars they do.

There is a very general notion in regard to animal charcoal; first, that it is very expensive; and secondly, that its use is attended with a great deal of extra labour and trouble. Now, nothing can be more mistaken than such impressions, as I think the following observations will demonstrate. Good grained animal charcoal can be purchased in London, at 13 shillings per cwt. and 2 cwts. will more than fill a filter of fourteen cubic feet; ten of which filters would be ample in a boiling-house, making six tons of sugar daily; the number of cwts. of charcoal therefore required would be 20, costing in London, 13*l.* *

The filter might be (on the make-shift principle) a common rum puncheon, with a false bottom about six inches from the real bottom, into which space a cock should be fitted for drawing off the syrup, and a bamboo air-tube might be fixed, for the air to escape through. The false bottom should have laid over it a piece of coarse flannel, blanket, baize, or some such common material, on which the charcoal, slightly moistened with water, should be very evenly and carefully laid; the whole being covered over with a piece of basket-work or coarse blanket.

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* New, best grained animal charcoal is sold by Messrs. R. Sorr & Son, (at their chemical works, Rotherhithe) at 13*l.* per ton; the packages may be in bags of one cwt., measuring two feet in length, by twenty-two inches in width, when

The "planter's own filter" is then ready for work; and certainly should not cost more than six dollars; making a total sum for ten filters with charcoal complete, of 25*l.*

This very moderate sum is the first cost, which by a little care need not be added to for a long time; as the charcoal can be most easily cleansed and completely restored, by the following simple method. After four or five successive charges of syrup have been decolourized, the charcoal will have become incapable of further action from the colouring and other organic matter it has abstracted from the syrup; hot water is then pumped into the filter, which takes from the charcoal the saccharine matter it has absorbed, and this water is returned to the first evaporator. A second charge of water is given, which, when drawn off, if not sweet and good, may be sent, by gutter, to the distil house. The charcoal is then emptied into a cleansing cistern (wooden), where it is left, with a small quantity of warm water, to ferment.

This process generally occupies from twenty to thirty hours (according to the quantity of gluten, colouring matter, &c. &c. that the charcoal has abstracted from the syrup), at the end of which time, all the organic matter has become decomposed; and the charcoal can then be cleaned by washing it in successive quantities of hot water, which will at last run off quite sweet and clean. All the water being drained off, the charcoal is taken out of the cistern, and laid in the sun, or some other hot place, where in a few moments it dries sufficiently to be returned to the filters.

Charcoal is well known to be a very indestructible substance. I therefore can see no reason why it should not last for many years, being repeatedly subjected to the fermenting and cleansing processes I have mentioned; and as to the puncheon filters, if they are honestly made in the first instance, they should last for many years also.

We see, then, that at the most trifling expense, and with the most ordinary care and attention, these animal charcoal filters may be erected, and continually worked, to the great improvement in the quality of the sugar made, and consequently to the great benefit of an estate! I think it must be conceded, that this decoloring of syrup by means of animal charcoal filters, is not such a very difficult undertaking after all! I even think we may go a little further, and allow it to be one of the most important, and at the same time most simple and inexpensive operations, attendant on the manufacture of sugar.

It requires no gift of prophecy to foretell, that in the course of a few short years every sugar estate will have animal charcoal filters erected in the boiling house: and well will it be for those estates which commence so palpable an improvement at once!

From the filters, the blanched syrup passes into a receiver, ready to charge either the concentrating apparatus termed Wetzal's (which I have already described at page 302), or the vacuum pan.

This latter apparatus is the celebrated invention of the Honourable Edward Charles Howard, and is now in very common use, notwithstanding its expense. Plate XVII. represents a copper vacuum pan and fittings, as manufactured by Messrs. Shears and Sons, of London. The plate gives a good idea of the various parts of the apparatus, which the following reference will render still more clear:—

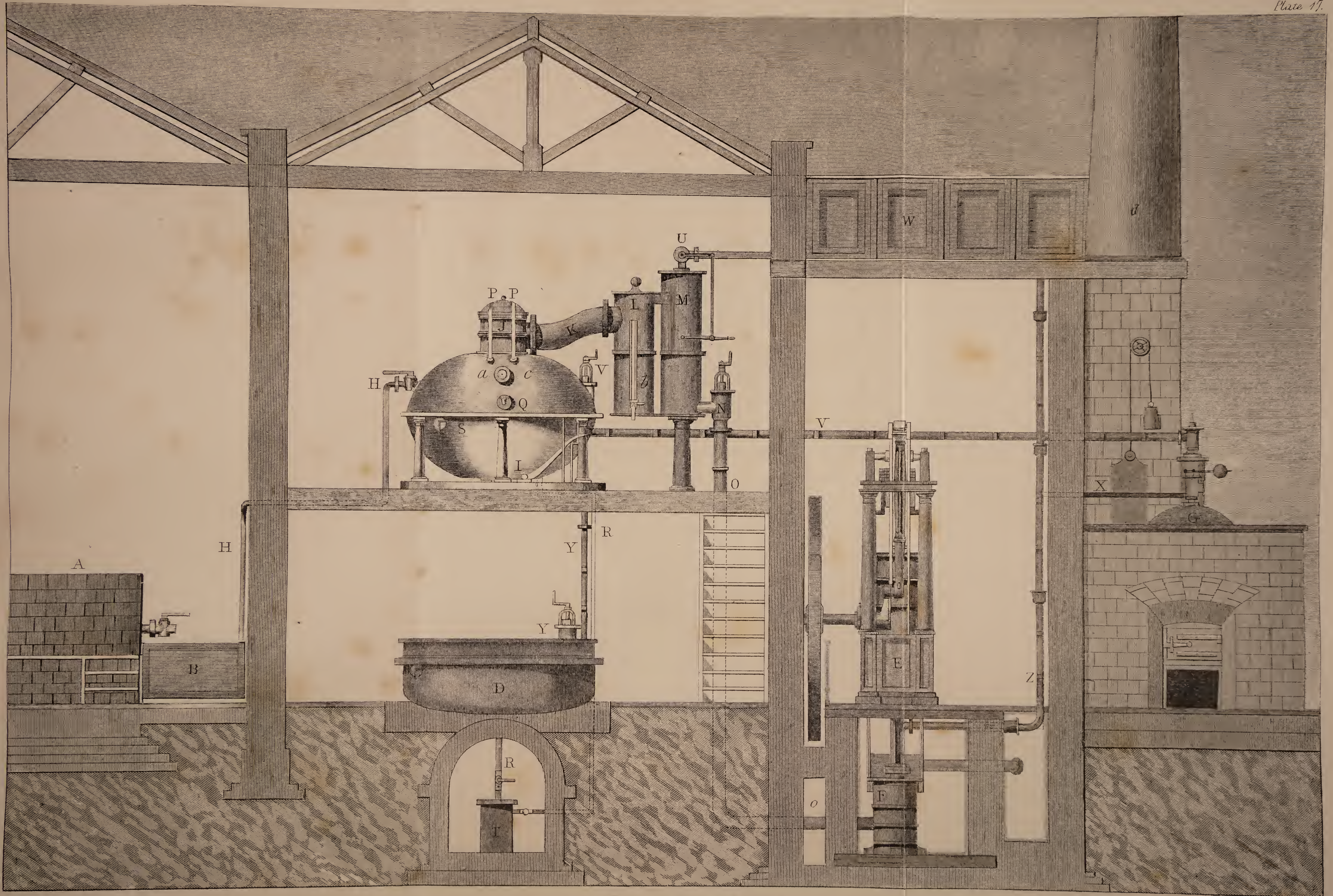
A The brick-work in which the tache is fixed (or on which the animal charcoal filters are placed), furnished with a discharging cock commanding the receiving cistern.

B Receiving cistern, for containing the liquor discharged from the tache.

C Copper vacuum pan, with a steam jacket, and containing several coils of steam pipe, with its attachments as described.

D Copper granulator, with a steam jacket, &c.

Plate 17.



Drawn by I. Holcroft.

Shears' Copper Vacuum Pan and Fittings.

Engraved by J. S. Porter.

E	Steam engine, for working air pump of pan, raising water, &c.
F	Air pump, for exhausting the vacuum pan.
G	Steam boiler set in brick-work, for working pan, granulator, and engine.
H	Charging pipe, through which the liquor ascends from cistern to pan.
I	Discharging valve and lever.
J	Man-hole and cover, for the convenience of cleaning pan when required.
K	Eduction pipe, through which the steam from sugar is conveyed to condenser.
L	Receiver, for any portion of sugar that may accidentally boil over.
M	Condenser, wherein the steam is condensed by a jet of cold water.
N	Air valve, through which the air exhausted from the pan, together with the condensed steam and injection water, passes to air pump.
OO	Connecting pipe to air pump.
PP	Barometer and thermometer, fixed on dome of Pan.
Q	The proof rod.
R	Pipe for conveying condensed water from steam jacket and worm to condensed water box.
S	An air cock.
T	Condensed water box, in which the condensed water from vacuum pan and granulator is received and returned into steam boiler.
U	An injection cock and pipe, which regulates the quantity of water required for condensing steam from the boiling sugar in pan.
VV	The steam main, supplying pan and granulator from steam boiler.
W	Water tank, for supplying boiler, injection water, and general purposes.
X	Pipe, conveying condensed water back to steam boiler.
Y	Steam pipe, to supply granulator.
Z	Pipe from cold water pump supplying tank.
a	Eye glass, fixed on dome of pan.
b	Glass tube, showing when the receiver contains any liquor.
d	The chimney.

This arrangement is not the precise one that I should select for a sugar estate; but it could scarcely have been placed better, for the purpose of illustration.

The principle of the vacuum pan is so universally known, that very little need be said on the subject here. The fact that liquids boil at a much lower temperature when relieved of the pressure of the atmosphere, is that of which Mr. Howard availed himself, if he did not actually first discover it: which we have every reason to believe he did.

This difference in practice may be stated as ranging between 150° and 212° Fahrenheit, with water; and 160° and 231° Fahr. with syrup: *id est*, syrup boils in vacuo, even up to concentration, at 160 degrees; whereas, in open pans, its temperature, when about concentration, is fully 231 degrees Fahrenheit. But in average working with the vacuum pan, its temperature is more commonly from 165° to 180° Fahrenheit.

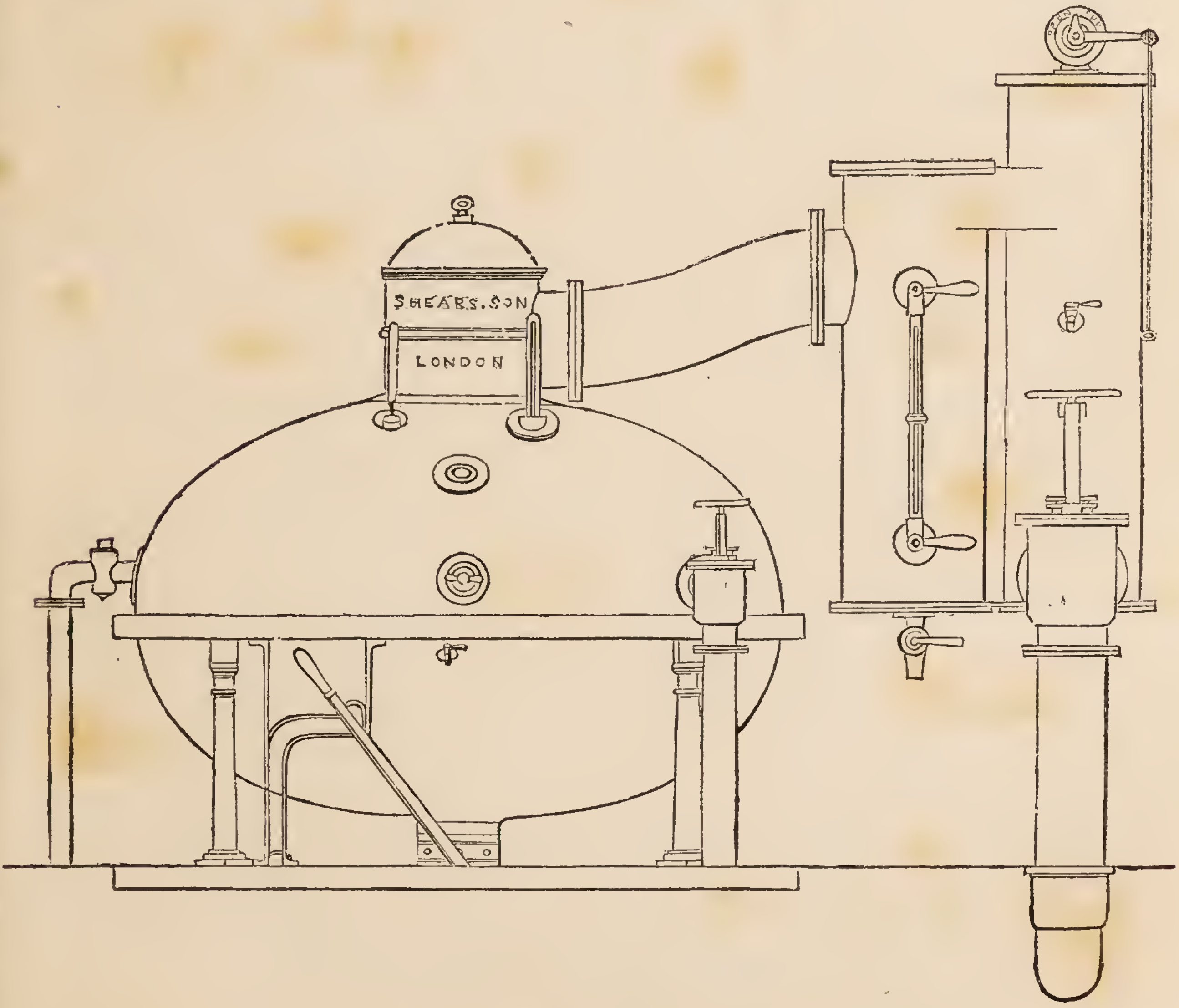
The evaporation of liquids embraces a number of well known yet very singular facts, which are found scattered through many books; but they seem to be very little heeded by the generality of people, although the business of many of these persons may be compromised by such inattention.

I will mention only one peculiar method of evaporation, which has much the same effect as creating a vacuum over a liquid. This is passing a current of dry air over the surface of any liquid: no matter how cold that air may be (so that it is above the freezing point), still the evaporation from the liquid will be similar to that which takes place under a vacuum.

If cold, dry air be forced through any liquid, and a current be likewise maintained over its surface, the evaporation proceeds at an extremely rapid rate. Hot air does not produce evaporation except it be dry; that is, its power of evaporating liquids depends on its state of dryness. But to vary the view: suppose a vessel heated by steam (and having a peculiarly formed top), were to have a goodly current of dry air constantly passing over its liquid contents, the evaporation would be as rapid as if the best vacuum were kept up over it; thus doing away with the condensing apparatus, &c. of a vacuum pan. An air pump, however, would be necessary to keep up the current of dry air, and a peculiar arrangement would be required to produce the dryness in the air supplied to the air pump; so that it is a question as to which method can be carried out practically at the least expense, and with the greatest effect. From everything that has already taken place, it would appear that the commonly used vacuum pan offers the greatest advantages; but I feel confident that the time is at hand when some material changes will take place in this respect.

I have seen a great number of vacuum pans of all sizes, and by many different manufacturers, but those of Messrs. Shears and Sons' have excited my admiration to a greater extent than any others. As a stranger, I have gone to their manufactory (in Southwark) at various times, and spent hours in viewing the different branches of their business. I have there examined vacuum pans in various stages of manufacture, and inspected closely the workmanship, in the several departments; from all which, I have formed a very high estimate of the character of their establishment; and I feel a pleasing gratification in adding my disinterested testimony to the support of their long established reputation.

To suit the requirements of a sugar estate, a vacuum pan might be either of copper or iron; of course the former is much more desirable, but still the latter will answer the purpose very well. I have therefore procured a drawing of an iron one exactly similar to those already supplied, by Messrs. Shears and Sons, for the Colonies.



SHEARS' IMPROVED VACUUM PAN.

An estate which had a good steam engine* would be fully able to work a vacuum pan without incurring an additional expense for engine power, &c.; therefore the bare vacuum pan, with its necessary fittings, would alone be required. Such a pan, 6½ feet in diameter, made of copper, and capable of turning out five tons of sugar per diem, would cost about 365*l.*; but if made of *iron*, with copper worms, the cost would be reduced about one-third, making it therefore about 243*l.* In the same manner, a copper vacuum pan, to make seven tons a day, would cost about 450*l.*, and an iron one about 300*l.* I do not aim at positive exactness in this statement: it is merely a rough estimate; calculated, however, to convey a tolerably correct idea of the expense of these pans.

The concentrated syrup, after leaving the vacuum pan, enters the granulators, where it remains until it has become granulated. These vessels are of such capacity as to contain about three skips from the pan, which are received at intervals, as the syrup is concentrated; the heat being kept up, by means of steam jackets, to the temperature of about 180 to 200 degrees Fahrenheit. Granulators may be of sheet iron, which answers the purpose very well.

Where the Wetzal pan is used instead of the vacuum pan, no granulators are used, but the sugar is usually run at once into large and shallow coolers. Of these coolers I need not say more in this place, than that they are no way suitable for the object that the planter has in view: the reasons for this assertion will be found in the next chapter.

Before quitting the boiling-house department, it is necessary that I should observe, that there ought to be (in addition to the peculiar roof for facilitating the immediate escape of the vapour rising from the evaporators, &c.) a thorough draft through the boiling-house; otherwise, the vapour hangs about the boilers so much as very seriously to impede the evaporation of the liquor. Therefore, the stronger the current of air through the boiling-house is, the better is it for evaporation: for it must be remembered that liquids will not evaporate (or at least very slowly) in an atmosphere loaded with moisture; such as a boiling-house must be, when it is filled with vapour.

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* Such as those I have already recommended.

This apparently trivial matter is, in my opinion, of such serious importance that I must particularly direct the attention of the planter to it.

The *Curing-house* forms a very important department in the manufacture of sugar, and its arrangements, therefore, should engage particular attention. Appertaining to the curing-house, it appears that there are three distinct processes through which the material must pass, ere it can be considered in a strictly marketable condition.

These comprise crystallization, drainage, and drying; to facilitate which, the curing-house should be divided into two unequal compartments: the larger for crystallization and drainage, and the smaller for drying the sugar previous to its being packed for sale or exportation. The former processes require light, warmth, and a certain degree of *moisture*, whilst the latter (drying) demands light, warmth, and *dryness*.

Of cones and curing cases, there is a very great variety to choose from; but as the peculiar form and dimensions most suitable, so greatly depend on the circumstances under which the syrup is concentrated, I shall leave the more particular discussion of that subject until I arrive at that part of the manufacturing process.

The Receivers for molasses also depend on the peculiar process of manufacture to which the sugar has been subjected for their form, size, and position.

Some curing-houses that I have seen in the east, are so extremely dark, cold, and damp, that one would suppose such characteristics had been particularly desired by the planter, to obtain some imaginary good: though I never could get any better reason than that glass windows were very expensive, and wooden rails and shutters dangerous, as they offered facilities for theft. But the absolute loss accruing in one year from such an injurious condition, amounts to a far greater sum than would suffice to purchase the glass necessary for windows; which, once furnished to the curing-house, would last for many years. Crown glass, such as sells in England at from 3d. to 4d. a foot, would be found sufficiently good to answer all purposes; using which, a curing-house of sixty-five feet long, and thirty-six feet wide, might have windows (six feet by four feet) at intervals of six feet apart: or say fifteen windows—the glass costing altogether only £6 (six pounds).

Very common glass only is necessary, therefore the sum of £6 is ample; but if we allow for breakage, &c. we cannot be far wrong, either way, in fixing the amount at £10, for a curing-house of the size I have instanced. In addition, we must, of course, reckon the cost of the wood-work, or sashes; which should be *fixed;* with one pane opening in the centre, to fasten the shutters at night. In the Straits settlements, the Chinese carpenters will supply such sashes (made of good wood) at two dollars (say eight shillings) each, contract work. In Bengal, they would not cost more than five shillings: but reckoning the sashes, together with painting and fixing the glasses, at an average sum of ten shillings each, then we have a total sum of £17 10*s.* as the cost of fifteen windows, complete.

Thus, if we allow £20 even, it certainly is not one-tenth of the amount lost out of every crop, through the absence of sufficient light and heat in the curing-house department.

The *Distil-houses,* represented in Plates VIII. and IX. are provided with skimmings' receivers, fermenting cisterns, rum butts, dunder receivers, and distilling apparatus.

The skimmings' receivers are wooden vessels, lined with sheet lead, to contain the scum from the evaporators, clarifiers, and precipitators; together with the washings of the two last, and of all other vessels used in the boiling-house. This refuse goes under the general name of skimmings, and is used, as will be described hereafter, in the manufacture of rum.

There should be two ranges of these receivers; the one placed above the other, so that the contents of the upper one may be drawn down into the lower, for clarification, previous to being used in "setting up" wash.

The fermenting cisterns are always made of good hard wood, of which the best for this purpose is Jamaica cedar: but in India, saul is used; and in the Straits, merboe, or other desirable wood. They should be constructed with much care, so as to be perfectly water-tight; and afterwards well coated over on the outside, with a mixture of dammer, tar, and oil, together with a little arsenic: which composition will effectually protect the wood against white ants. These cisterns are then placed in lines (as shown) of about two feet apart, leaving in the centre of the house a space of six feet wide, running the whole length of the fermenting house. The spaces between the cisterns, as well as that in the centre, are next filled in with good dry clay (to a level with the top of the cisterns), and well rammed, so as to be perfectly firm and solid.

In this manner, these spaces form paths between the cisterns, by means of which the workmen can perform their necessary duties with facility. The lower range of skimmings' receivers is just above the level of the top of the cisterns, so that the skimmings can be drawn down and conveyed by gutter, into either cistern in the house.

To empty the cistern, when the wash is required for distillation, a common pump alone is required; and if this work has to be performed by hand labour, there should always be a wash-heater, or charger, attached to the still, by means of which much economy of time and fuel may be effected. Wherever a steam-engine is employed to propel the mill, a very simple arrangement would allow of all the pumping in the distil-house being performed by the engine power: provided the manufactory were constructed on either of the plans recommended. This will be explained in detail as we proceed.

The size of the fermenting cisterns may vary according to circumstances: but for my own part, I always found those containing from 1,000 to 1,500 gallons to be the most convenient and efficient. Cisterns are always preferable to the old-fashioned tuns.

Rum butts have, of late years, become rather scarce in colonial rum stores, owing to the necessity there exists for bringing to market, as soon as possible, the rum made on estates: hence it very frequently happens that the spirit is carried from the can-pit direct to the puncheon, or hogshead; there coloured, and at once sent off, either to market or to the port, for shipment, without going into the rum butt at all.

It is, however, convenient to have a few 300 or 500 gallon butts at hand to keep the rum in; both to prevent lumbering the store with a number of puncheons, and also as rum can be more satisfactorily coloured in butts than in puncheons.

The dunder receivers are strong, wooden vessels, for containing the dunder (wash, from which the spirit has been extracted), as it is discharged from the still. They are generally made, each, to contain the same quantity as the still itself; so that, by the time the still has worked off two charges and part of a third, the contents of the first dunder receiver are cool enough to be pumped up into the upper range, and so on.

The different kinds of stills now in use are so very numerous, that it is quite impossible for me to name them even; but from amongst this great variety, it will be sufficient to particularize a few of the most prominent.

In the first rank of English stills, we have the single and double (patent) stills of Messrs. Shears and Sons; the illustration and description of which I shall defer until I come to the manufacture of rum, in a succeeding chapter. Next, we have the steam stills of Mr. Coffey, several of which I have seen in operation in India; but I cannot say that it is by any means the description of still I should choose myself, or recommend to others, for use on a sugar estate. It no doubt may answer very well in Europe, but those that I have seen were always getting out of order; which, in a country far removed from skilful workmen, entails on the planter serious inconvenience and loss.

The common single still and two retorts, together comprise the particular form that I have been most accustomed to; and, as far as my own experience goes, I prefer it to any other description of still. With a 1,000 gallons still and two retorts (of about 80 and 70 gallons respectively), I have obtained 320 gallons of rum thirty-five per cent. over proof, in twelve hours running; and if there had been a wash-heater, it would have given fully 400 gallons in the same time.

The cost of such a still, complete, would be about 450*l.* in England. They are in great repute in the colonies, and most deservedly so. Messrs. Shears and Sons are at present supplying several of them for Jamaica and other islands.

The French stills, invented, the one by Mon. Blumenthal, and the other by Mon. Langier, bear the very highest reputation for economy of fuel, expedition, and general efficiency. They are both on the continuous distillation principle, and I shall, in a succeeding chapter, have occasion to refer to them, as well as the others, again, and more particularly.

A distil-house should be dry and moderately warm; there should not be too great a heat in the fermenting room, as in this case a very large quantity of alcohol is evaporized from the cisterns, by the fermentation being too vigorous. Neither should too strong a light be admitted, for the same reason. These cautions will serve to remind the planter, that the fermentation which best conduces to his interests, is that which is moderate and complete throughout the liquor, without being excessively furious; as is sometimes the case in a distil-house which is kept too light and hot.

On the other hand, a damp and cold house is not to be tolerated, nor a proper ventilation neglected. However, the further discussion of these particulars more properly belongs to an after chapter.

CHAPTER VIII.

ON THE MANUFACTURE OF SUGAR; EMBRACING THE CRUSHING OF THE CANE AND THE CONSTITUENTS OF CANE-JUICE; TOGETHER WITH THE PROCESSES OF DEFECATION, EVAPORATION, CONCENTRATION, GRANULATION, AND CURING.

In the manufacture of the sugar-cane juice into sugar, we first have to deal with the sugar-cane itself; and its crushing, or the expression of its juice, in the mill-house, therefore, forms the first stage in its progress towards ultimate concentration.

It is, next, necessary to determine what are the substances usually commingled and known under the name of raw cane-juice; for unless we can arrive at a tolerably clear recognition of these constituents, and their peculiar characters, we cannot reasonably hope to succeed in the important process of defecation.

These two subjects, then, form our introduction to the details of manufacture to be treated of in this chapter.

The canes should never exceed four to five feet in length when they are placed on the feeding board of the mill; otherwise they invariably cause inconvenience, and very frequently (from being crooked) "overlapping," in spite of all that the feeders can do to prevent it. The prevention of these serious evils rests with the cane-cutters in the field; who, as they cut the canes from the stools, should be careful in dividing them into desirable lengths. Arrived on the feeding-board, the cane-carriers remove the cane-bands with which the bundles are tied; and the feeders must take the greatest care to arrange the canes along the whole length of the rollers, in a regular and even manner. By so doing, twenty-two canes of average size can be very conveniently laid, and be crushed at the same time; supposing the rollers to be four feet in length.

A greater number may be placed at once in the mill, but not conveniently, nor do I think advisably; the great point in feeding being to supply, immediately and cleverly, the place of each cane as it disappears through the mill, so that, reckoned at any moment, the self-same number of canes (twenty-two) will be found passing through the mill. This forms the great difference between the but too common and negligent feeding, which at times crams the mill with perhaps thirty-five canes, whilst at others it has not more than two or three presented to it. The feeding, then, best calculated to produce a large quantity of juice, the steady working of the engine, the least liability to breakage, or the least possible wear and tear of the machinery, is that which is regular, uniform, and moderate.

The feeder who directs and assists the course of the saturated cane-stalks towards the second set of rollers, has little more to do than to see that they enter the rollers in a straight and desirable manner. If these rollers are screwed up as tight as they should be, there can be no necessity for his doubling the saturated stalks; as they will not be able, under any circumstances, to pass through the rollers without being thoroughly crushed.

It may be deemed desirable to separate the pure juice expressed, from that of the saturated canes, as so much water is mixed with it; but if intended for immediate manufacture, I do not consider that any good is to be gained by such separation. Indeed, under any circumstances, cane-juice should be clarified immediately it is expressed; or if necessary to keep it for any length of time, fermentation can readily be prevented by very simple means. I therefore do not perceive any ill effect that can arise from the juice, from the two sets of mill rollers being allowed to intermingle.

An important duty appertaining to the mill-house, is to keep the mill-bed constantly free from bits of cane-trash (which are continually falling from the rollers); otherwise, in the course of a very short time, they become acid, and communicate a taint to the juice. The mill-bed, therefore, should be cleaned every five or ten minutes; which can be performed by a boy, whose duty should consist in cleaning the mill-bed, juice-gutters, and strainers.

As the juice runs from the mill-bed, it falls into the first, second, and third strainers, in succession; each lying on a step lower than the other, and the material of each strainer being finer that that of the one above it. Thus there is a fall of twenty-one inches, obtained by means of three steps of seven inches each; which steps allow of a small receptacle being made, on each of them, of about two feet square, having raised edges of about two inches high, and a lip protruding over the space occupied by the next (lower) step. Into these spaces of two feet square, the strainers (which are only twenty-two inches square) fit, resting on their lower rims of one inch; so that the bottoms of the strainers are one inch raised above the bottoms or beds of the receptacles. To prevent acidity, sheet lead is used in forming these beds or receptacles; and they are constantly cleared of all matter likely to cause acidity.

A frame-work answers all the purposes above described, provided the strainers rest on beds of sheet lead. The third or lowest strainer should be of fine wire-gauze; passing through which the juice is cleared of a large quantity of extraneous matter; and a further portion is retained in the last and finest strainer, which hangs over the clarifier.

The juice being now in the boiling-house, we will, previous to tracing it further, proceed to notice the substances it contains.

Cane-juice, as it arrives in the boiling-house, may be held to contain—

Water,
Sugar,
Woody fibre,
Gluten,
Green fecula,
Green wax (chlorophylle),
Gum,
Saline matter.

The several qualities vary very much, according to the circumstances under which the cane-plants are grown, and the degree of maturity to which they have arrived at the period of their being cut.

I have not, therefore, stated any proportional parts, as these evidently depend on the many conditions that influence the plant; and no regular and fixed standard can be taken. I shall state, as I proceed, the parts proved by analyses to exist in cane-juice of good and inferior qualities; but from those it would be difficult, if not impossible, to deduce anything like an average division, which could be admitted as a rule in practice.

Water contained in cane-juice varies from seventy to eighty-five parts in 100, and may all be evaporated, except the portion necessary to crystallization.

Sugar resident in expressed juice ranged from five degrees to fourteen degrees of Baume's saccharometer; *id est*, from about 9 lbs. to about 25 lbs. per cent. I myself have never known it so high as 25 per cent.: nor, indeed, higher than 23 lbs.; although it is very probable that juice fully as rich as the former per-centage would make it, may have passed through my hands, without my having been aware of it, during the earlier part of my life as a planter.

It is, however, mentioned by Dutrone (whose testimony and opinions are entitled to the utmost respect and credence), that on the same plantation he obtained from canes, at one period of the year, 9 lbs. 3 oz. only, from 100 lbs. of juice; whereas, at another and more favourable time, he obtained from a similar quantity of juice, 25 lbs.

11 oz. of sugar. I have myself known a variation on one plantation, of from eleven to twenty-two per cent. of sugar.

The saccharometer denotes the *density* of cane-juice; but the actual quantity of crystallizable matter will depend on the purity of the juice, and its freedom from nitrogenized and saline matters. Thus, taking juice of a density of ten degrees by the saccharometer,* equal to $18\frac{1}{3}$ lbs. of solid extractive matter, we must allow fully $1\frac{1}{2}$ lb. as being uncrystallizable; and in many cases far more.

Sugar exists in the cells of the cane-plant, as I have before remarked, both in the form of a limpid fluid, and also as a concrete formation; that is to say, that this limpid saccharine crystallizable fluid, under favourable circumstances (as a congenial soil, and during hot, dry weather), becomes so rich, and so perfectly elaborated, that it deposits minute but distinct crystals around the cells which contain it; and these crystals are seen adhering to the whole of the inner membrane of the cells. If there were any means of extracting this matter (both fluid and crystalline), without causing an admixture with the other substances forming the sap of the cane, no doubt but we should be able to obtain a perfectly pure and crystallized sugar by means of simple evaporation alone. But it unfortunately occurs, that, by the mode of expression now universally adopted, not only is the saccharine crystallizable fluid mixed up with the nitrogenized and other matters, to its great injury, but the crystals of sugar which have been already deposited in the cells are, for the most part, left in the cane-trash, adhering to the cellular membranes.

From this latter cause it is, that a saturation of the cane-stalks with hot water is advised, previous to their undergoing the final pressure by the second set of mill-rollers.

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* At a temperature of 60 degrees; but at a temperature of 84 degrees, as is common in the sugar growing colonies, a density of 10 degrees by the saccharometer, denotes fully 18 per cent. of pure sugar.

Woody fibre, or *lignin*, are terms used to designate the solid structure of the cane-stalk, particles of which become intermixed with the cane-juice, from the breaking down and crushing which the stalk undergoes whilst passing through the mill. Some of these particles are so large and coarse, as to be easily retained by the wire-gauze strainers, through which the juice runs on its passage from the mill to the clarifiers; whereas others, again, are so finely comminuted, that they pass through the strainers into the clarifier.

Many authors draw a marked distinction between woody fibre and the cellular tissue of plants: which latter they name cellulose; but it does not appear that there are any just grounds for so separating them; for they are as identical in composition with one another, as the woody fibre or cellular tissue of one plant is identical with similar substances of other plants. There is, however, a decided difference between the composition of wood, and that of woody fibre (properly so called); as in the former from three to five per cent. of foreign substances are comprised, which of course have no existence in the composition of the latter. Besides which, in analyzing woody fibre and cellular tissue, and comparing results, the nature and properties of the substances which had been contained in the cells of the latter, are but too frequently lost sight of; although, on reflection, it is evident that the results of the analysis must be influenced by these substances. For instance, in the cane-plant there are cells in which the saccharine fluid is elaborated, and even sugar deposited; there are also various other cells, in which various other organizations are carried on: it therefore occurs, that according to the peculiar nature of the different substances organized in these cells, so is this cellular tissue more or less encrusted, and impregnated by them; consequently affording different results under analysis.

Hence the relative proportions of carbon, oxygen, and hydrogen, are found to differ; and erroneous deductions are drawn therefrom, to the mystification and confusion of the general reader.

The very minutely-divided particles of woody fibre that are existent in the cane-juice which enters the clarifier, are more or less enveloped by matter, which causes them readily to rise to the surface of the liquid during the process of clarification: I have even seen a large quantity rise to the surface in the cold receivers. There is, then, no difficulty in getting rid of this substance.

Gluten is a substance that presents itself under varied forms, according to the manner in which it is acted on by the different matters with which it comes in contact. This circumstance has furnished a befitting opportunity for chemists to enrich their nomenclature with many singular new names: thus we have gluten, zimome, gliadine, legumine, vegetable albumen, fibrine, caseine, diastase, *cum multis aliis!*

Now, the planter will not be displeased to learn, that, notwithstanding this formidable array of names, they all resolve themselves into one substance—*gluten;* but as the term vegetable albumen is very commonly used, I shall employ that designation, as well as gluten, whenever I find occasion to do so: it being understood that they are one and the same substance. In cane-juice, gluten exists in solution, until the acid which holds it dissolved is evaporated by means of heat, or by saturating it with an alkaline solution; which causes the gluten to become insoluble or coagulated, so that its particles, meeting together, adhere to each other, and rise to the surface in the form of thick scum, which is often called vegetable albumen. All cane-juice contains a proportion of the free acids: at times so great that, on leaving the mill, it produces a slightly acid reaction on litmus paper; whereas, generally, they are not to be detected by that test, being combined with gluten, &c. so as to present no symptoms of their existence. But on the application of an alkali (temper lime), a union immediately takes place between the alkali and the acid, and the gluten forthwith assumes the form of coagula, and becomes insoluble in water. A further application of alkali would have the effect of re-dissolving the coagulated gluten, and holding it in a state of solution; until an acid re-agent could be used to saturate the alkali, which would cause the gluten once more to assume the form of coagula. Thus we see that a very great deal of nicety is required in what is termed tempering cane-juice, or cane-liquor ; and we perceive at once one great reason why it is that an alkaline menstruum (temper) in excess is so injurious : viz. as being not only sufficient to saturate the acid which holds the gluten dissolved, but effecting the re-solution of the coagula about to form.*

Again, we find that by subjecting fresh cane-juice to a moderate heat (of from 140 to 168 degrees Fahr.), the volatile acids holding the gluten in solution are disengaged and evaporated, leaving the gluten in the form of flaky coagula. There has been a very great deal of argument amongst the most eminent chemists, as to the fact of an acid being present in cane-juice; as well as to the nature of that acid. Bergman appears to have been the first who ascribed the utility of lime (temper) in sugar manufacture, to its action on the acids contained (in combination) in the juice of the cane. Proust declared the presence of large quantities of malic acid in cane-juice, analyzed by him in Spain. Dr. Higgins, following the same idea of an acid being present, expressed it as his opinion that the fecula (meaning gluten) in cane-juice was held in solution partly by water, and partly by carbonic acid ; which acid was expelled when the juice was subjected to a heat of 145 degrees Fahr., and the fecula forthwith rose to the surface as a coagulated scum. He also held that the application of lime would have the same effect on the fecula; only that it would enter into combination with the carbonic acid, forming carbonate of lime. Raspail says, "The saccharine substance does not exist alone in solution in the sap of any plant, in sufficient abundance to afford a lucrative return for the trouble of extraction. It is accompanied by gum, different salts, and various acids, which the current of the vascular circulation carries along. Besides, as in most cases this juice is obtained by expression, it necessarily carries with it the green fecula, and fragments both of the ligneous and glutinous textures; and these last (glutinous textures) may then become more or less soluble, and assume more or less the character of mucilage, by combining with the free acids of the saccharine solution. I am persuaded that the lime that is used in the extraction of sugar is of no other use than to saturate these acids, and thus restore to the gluten its original insolubility, so that it may coagulate and be skimmed off; enveloping in its substance all those textures impregnated with green or gummy matter; and that in this way it acts as the first means of clarification."

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* It has been shown by Liebig, Raspail, and other celebrated chemists, that gluten, or vegetable albumen, contains nitrogen in the form of an ammoniacal salt, which is decomposed by the action of heat, or of an alkali (as lime).

I consider it quite useless to multiply instances of opinions similar to these: nor do I deem it of any use mentioning others of a contrary tendency; for it may, in my opinion, be held as quite clear, that although cane-juice may present no appearance of an acid—not even to affect litmus paper in any way—yet that the action of an alkaline solution, or of heat, will at once make manifest its actual presence. The reason of this, as I before said, is because the acid is in combination with the glutinous textures (gluten), which it keeps dissolved.

The action of heat certainly disengages the acid, and causes the gluten or albumen to assume the form and character of coagula; but it is by no means certain that the acid in all cases is evaporated: this appears to me to depend on the nature of the particular acid in combination with the gluten; for we find, in very good cane-juice, that a moderate heat is sufficient to expel the acid, and coagulate the gluten (thus clarifying the juice); and that a further heat in the boilers will bring it to a state of concentration, and excellent sugar will result, without a particle of lime being used from first to last.*

How does this happen, unless it be that the acid is of a very volatile nature; so that, on the application of a moderate heat, it not only becomes disengaged from the glutinous textures, but is entirely expelled (evaporated) from the liquid, leaving these glutinous textures to subside as precipitates, or rise to the surface as scum.

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* The juice of canes grown on a calcareous soil, or on a soil which does not furnish ammonia in excess (nor has had it applied in manures), is found to contain very little gluten, and, consequently, will very frequently furnish good sugar, without any lime being used.

In this case, the use of lime would do a positive harm, as the acid has evaporated; and the feculencies being entirely separated, nothing is left for it to act on but the sugar, which it would therefore decompose.

The case is clear, that, as the acid has been expelled, and the feculencies entirely removed, nothing remains to be done, but to evaporate the water which holds the sugar in solution.

On the other hand, cane-juice at times contains an acid which is not of the volatile character above denoted; for instance, fresh cane-juice has been known to shew no symptoms of acidity when tested with litmus paper, but after being (carefully) clarified by heat alone, the liquor was found to be decidedly acid, palpably affecting litmus paper: and on a further clarification (in another clarifier) by heat, *id est*, the heat being carried to the boiling point, a thick scum was thrown up; which being skimmed off, the liquor was found to be very perceptibly increased in acidity. A solution of lime being added, until the liquor assumed a neutral character, a very slight scum arose; but on making the liquor rather more alkaline, a further quantity of scum rose to the surface: but not any great portion. This liquor, concentrated, furnished ordinary sugar, but a large proportion of molasses; which arose from the defecation being incomplete, and from the disengaged acids having decomposed a portion of the sugar, and changed it into glucose.

Some of the same kind of juice clarified (at the same time) by means of lime and heat, and in the boilers treated with a further supply of lime, boiled well, and gave good sugar; much better than the former, and with far less molasses.

These facts proved to me, that in certain cases the acid is by no means volatile; and I am sure that the experience of numerous planters can attest the formation (if I may be allowed the term) of an acid subsequent to clarification, which induces the boilermen to put lime in the second tache even. The error committed in the first of the two experiments just recited was, that on the appearance of an acid reaction on litmus paper, the second clarification should have been effected by means of lime water, whilst the heat was kept as before; but by applying no lime, and increasing the heat until the liquor boiled, of course the separation of the flocculent coagula was rendered impracticable, except by subsidence or filtration; which even would have been but partially successful, seeing that the liquor was so acid.

These facts lead us to judge, that in the coagulations of the glutinous textures contained in cane-juice, certain acids are set free, the character of which is at times extremely volatile; whilst at others they are not so. The saccharometer and thermometer are instruments of great utility and value to the sugar manufacturer; and I think the possession of other two instruments would greatly facilitate the operations in the boiling-house, and render them much more certain and secure from loss. The instruments I allude to are an *alkalimeter* and an *acidimeter;* the one to denote an excess of alkali, and the other an excess of acid. In the transformations which are effected in cane-liquor during clarification and subsequent evaporation, we have not only those produced by lime-water, but also those produced by the action of heat.

By the present modes of manufacture pursued in Colonial boiling-houses, no certainty attends the operation; even the many years of experience and constant practice do not suffice to assure the oldest boilermen, in cases where the liquor is bad and intractable. But were instruments of the kind named, placed in the hands of an ordinarily intelligent boilerman, no hesitation or difficulty would be felt. I much fear that such a result could not be hoped for from the use of litmus paper, as its employment could scarcely be entrusted to negro or native boilermen.

The acids which discover themselves during the process of evaporation, appear to be altogether ascribable to the presence of gluten or other azotized compounds still remaining in the cane-liquor; for if a solution of pure sugar be evaporated at ordinary temperatures, no acidity results.

Gluten contains nitrogen in the form of ammonia; and it is asserted that during the evaporation of cane-juice at a high temperature, a portion of this ammonia is evaporated and a portion is decomposed, hydrogen gas being evolved, and the liberated nitrogen immediately combining with the oxygen of the liquid, forming nitric acid. It is likewise believed, that cane-liquor containing gluten evolves carbonic acid gas during evaporation at a high temperature, by the carbon of the gluten absorbing the oxygen of the water, which it immediately gives off as carbonic acid gas; and that, as the process of evaporation proceeds towards concentration (that is to say, when the cane-liquor has become syrup), the carbon of the gluten continues its absorption of oxygen; which, however, is no longer derived from the water, but from the sugar, which, by the extraction of its oxygen, it decomposes: hence sugar containing gluten is always undergoing decomposition. Indeed the nature of gluten,* its numerous transformations and its peculiar properties, have furnished matter for unlimited arguments, which certainly fill many volumes; it is not therefore desirable to enter more at length than I have done, into such an interminable subject, but I hope what I have stated will suffice to convey to the planter all the information he requires on this point.

A menstruum composed of creosote very much diluted with water, has the effect of coagulating gluten (in its various forms) to a remarkable degree; the knowledge of which fact leads me to imagine that it may possibly be useful in defecating cane-juice. But the most delicate test that we have of the presence of albumen (*ergo* gluten) in any liquid, is corrosive-sublimate (bi-chloride of mercury), which is so extremely effectual, that if a single drop of the saturated solution of corrosive-sublimate be let fall into a liquid containing only the two-thousandth part of albumen, it will immediately occasion a milkiness, and produce a white, curdy precipitate. Corrosive-sublimate is, however, one of the most virulent poisons that we know of, and the bare mention of its use in clarification may occasion great dread; but I am by no means certain that it may not be used by a careful operator with success.

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* Gluten is coagulated by alcohol; sulphuric, and other acid; lime, and other alkalis.

Speaking of its employment for the removal of whatever vegetable albumen (gluten) remains in cane-liquor after clarification in the first clarifier, I will suppose that a very dilute solution of corrosive-sublimate be (gradually) added to such liquor, until the curdy coagula present themselves; and then an alkaline solution (lime water), to saturate the acid set free.

In this case, the vegetable albumen instantly combines with the calomel in the corrosive-sublimate, forming a white flocculent precipitate; whilst a portion of hydrochloric acid, is set free, which is immediately rendered neutral by the lime, with which it combines. Orfila has proved by experiment, that the precipitate in cases of this kind, is a compound of calomel and albumen, which is entirely inert.* I do not, of course, imagine that such an agent as this can be employed in boiling-houses: but the facts stated are very interesting to the inquiring and intelligent planter.

Green fecula, so called, in cane-juice, consists of oval vesicles of very variable form and size, full of green globules, whose office appears to be, to afford nourishment to the buds or "eyes" of the plant during the progress of germination. In certain stages of the canes' growth, and under peculiar circumstances, this green fecula abounds; imparting to the cane-juice a very green tint. Mere boiling does not appear to deprive these vesicles of their green matter; but the application of various substances has that effect.

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* Toxicologie, vol. i.

Heat produces an expansion of the vesicle, which causes it readily to rise to the surface, together with the ligneous and glutinous textures contained in the juice, in the form of scum.

Lime combines with green fecula and causes a subsidence, which usually takes place simultaneous with the gummy and glutinous coagula. All fleshy plants furnish a large quantity of green fecula, by mechanically breaking down their cellular tissue, as is done in crushing canes.

Green colouring matter, (chlorophyle) green wax, sometimes termed extractive matter, is but a variety of the same genus as the above (green fecula). It has been classed by some among the resins, and by others with the fatty matters; but established facts prove it to be, in reality, a variety of wax. The colouring matter appears to be distinct from the waxy matter with which it is associated, as the greater number of re-agents act on the one, without in any way affecting the other.

This substance varies in colour according to the degree of maturity and perfection to which the plant, whence it is derived, has arrived; thus we see it varying from a deep green, through the several shades, until it terminates in a yellow colour. The colouring principle would seem to be due to the presence and action of ammonia in combination with manganese or iron.

Those colouring matters commonly called extractive matters, are generally nothing else than more or less complicated mixtures of various modifications of the green colouring matter, with some substance, either fatty or albuminous.*

Heat has the effect of keeping these matters dispersed through the liquor; but lime-water tends to unite and harden them, so that a large portion of them is taken off with the scum.

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* Raspail.

Alumina combines with colouring matter, and forms a precipitate.

Gum, as existing in expressed cane-juice, is in the form of mucilage, and results from the presence of the glutinous and woody textures with which it is intermixed; thus, in consequence of the crushing and complete breaking down which the canes undergo in passing through the mill, a portion of the gluten and of the debris of the woody textures, are mechanically incorporated with the gummy matter, altogether forming a mucilaginous mixture. Alcohol, acids, and alkalies coagulate gummy matter; and sulphuric acid has the property of converting it into sugar.

Saline matters, present in cane-juice, depend very much on the soil on which the canes are grown; as, for instance, in the low alluvial soils of Demerara, Louisiana, the Sonderbunds (below Calcutta), and Province Wellesley, canes often imbibe so much saline matter from the soil, that the sugar made from them may be said to be in a constant state of deliquescence.

The analysis of the juice of canes grown in Louisiana, which is given at page 44, shews the quantities in which they may be contained; but in the Sonderbunds near Calcutta, and the Province of Wellesley, the juice is often even much more affected.

The cultivation of the cane had to be entirely relinquished in the former of the two places on this account; and the sugar sent home from the latter has in many instances been so extremely deliquescent as to occasion very extensive loss.

Soils manured with wood-ashes in excess produce the same pernicious results, from the saline matters they furnish to the cane plants. The chlorides of sodium and potassium, sulphates of potash, &c. &c. &c. are amongst the chief which exercise so pernicious an influence on cane-sugar.

Peligot says that one part of the chloride of sodium will combine with nearly six times its bulk of sugar, forming a deliquescent compound, which is capable of liquefying another portion of sugar, equal to itself in bulk; and from my own observation, I believe this deliquescence to continue, until the whole mass of sugar is decomposed. It is stated on authority, that such saline matters once present in cane-juice cannot be got rid of by any means; and I believe that this is so far correct in regard to actual practice on a large scale: but in the laboratory of the chemist, I do not see that so great a difficulty exists; for we know that hydrochloric and muriatic acids, and chloride of sodium, are powerfully acted on even by a very small quantity of nitrate of silver. In the case of chloride of sodium being present in any liquid, on nitrate of silver being added, inert chloride of silver is immediately precipitated.*

Dr. Ure says, "nitrate of silver is such a delicate reagent of hydrochloric or muriatic acid, as to shew by a sensible cloud the presence of one 113-millionth part of it, or one 7-millionth part of sea-salt in distilled water." This would lead to the supposition that (at least in the laboratory of the chemist) the more particularly pernicious (sea-salt) of the saline matters can be separated from cane-juice by the aid of nitrate of silver.

We can readily perceive, from the brief glance we have taken of the constituents of cane-juice, that the object of the planter should be, to separate as early, and in as effectual a manner as possible, the undesirable matters comprised under the head of woody fibre, gluten, green fecula, green wax (chlorophyle), gum, and saline substances; leaving the remaining sugar and water in as pure and simple a state as may be.

Comprised of such substances as these just enumerated, it may readily be supposed that cane-juice is one of the most fermentable compounds possible; and experience shows that in half an hour after expression an incipient vinous fermentation commences. This is often apparent in the vessels used in the West Indies, and called cold receivers; wherein the fresh juice is received as it runs from the mill, and retained, until there is room in the clarifiers to allow of its being drawn down. It often occurs that juice is so kept for a long time; but if the period extends beyond twenty or thirty minutes, the pan-man (attendant on the defecators), always uses a little lime to prevent fermentation, until it can be received in the clarifiers.

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* Raspail.

There are some planters who argue that a slight fermentation of the juice previous to clarification, tends to promote that important operation, and that the liquor clarified under such circumstances "boils well," and produces good sugar. Others insist that the fermentation should be, after the juice has been clarified, but previous to its being boiled. This latter opinion, at least, seems to have arisen out of a statement made by Dutrone, who writes, "I have twice obtained very fine sugar from juice partially clarified, which had undergone a vinous fermentation during eighteen or twenty hours." On this Porter has a paragraph (page 56), which appears to carry with it a recommendation of such a system. Dutrone simply stated a fact, which admits of ready explanation; but it is one that certainly is far from being advantageous to the planter.

If raw cane-juice be allowed to remain exposed to the air, in a short time a fermentation commences, which is of the vinous order; but in another very short time, the acetous fermentation likewise begins, and continues in conjunction with the vinous: that is to say, that the glutinous fecula or ferment contained in the juice, decomposes the sugar, converting it into alcohol, which immediately attacks the glutinous ferment, and precipitates a large portion of it; the alcohol being itself converted, by the action of so large a body of ferment, into vinegar and water. Thus the alcohol formed by the vinous fermentation, is, in the case of raw cane-juice, decomposed and changed into vinegar almost as soon as it is formed!

In the case of partially clarified cane-liquor, that is, cane-juice which has been clarified to the extent it usually is in

West India boiling-houses, a longer time is requisite to bring on fermentation than in the raw juice, although it is still very quick. Now, in this partially clarified liquor, there is still a quantity of glutinous ferment that has not been separated, and this, acting on the sugar, causes a vinous fermentation, with the consequent formation of alcohol; but in this case, the alcohol formed being in excess and the ferment in comparatively small proportion, the latter is thrown down as a precipitate, and a very much longer time is necessary to bring on the acetous fermentation than in the former instance: indeed, we may almost say that this latter fermentation does not commence until the vinous fermentation has ceased.

Partially clarified cane-liquor, then, being permitted to undergo the vinous fermentation during some time, has a large portion of its glutinous fecula precipitated by the action of the alcohol on it; and thus, if carefully drawn off (leaving the precipitate behind), and immediately boiled down to concentration, no doubt the result will be "fine sugar." But it must be borne in mind, that the alcohol which here acts as a precipitant is formed altogether at the expense of the sugar contained in the cane-liquor, and, consequently, it is a course that no one should do otherwise than condemn. In regard to the fermentation of the raw juice, as noticed, no good can by any possibility result.

If it be considered desirable to keep raw cane-juice for any length of time, fermentation may be prevented by the use of sulphurous acid. On this subject, Dr. Ure says, "It is known that grape-must, feebly impregnated with sulphurous acid, by running it slowly into a cask in which a few sulphur matches have been burned, will keep without alteration for a year; and if '*must*' so muted be boiled into a syrup within a week or ten days, it retains no sulphurous odour. A very slight muting would suffice for the most fermentable cane-juice,* and it could be easily given by burning a sulphur match within the cistern immediately before charging it from the mill. The cane-juice should, in this case, be heated in the clarifier, so as to expel the sulphurous acid, before adding the temper-lime; for otherwise a little calcareous sulphite might be introduced into the sugar. Thus the arescence so prejudicial to the saccharine granulation would be certainly prevented." The sulphurous acid (not sulphuric acid) acts directly on the glutinous ferment, and renders it inoperative: a fact the planter may find it to his benefit to avail himself of, in certain situations which uncontrollable circumstances may place him in.

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* As cane-juice is not nearly so fermentable as grape-must.—*Author.*

Many persons imagine that a great good would result from being able to filter cane-juice previous to the application of heat, without incurring the risk of fermentation supervening: others (even scientific men) argue that such a system cannot be carried out practically on a large scale; whilst, for my own part, I cannot discover why cane-juice (being muted with sulphurous acid) should not be able to undergo filtration without being liable to fermentation. I have never tried this, but it appears to me, that if a slight muting with sulphurous acid will prevent fermentation in cold cane-juice for a long period, then that a portion of that period might be availed of to perform the filtration through bag-filters; keeping the liquor cold (as it comes from the mill) during the process. But it is well known that cane-juice so treated will very rarely crystallize as it should do when concentrated, unless some substance has been used to assist granulation; *id est*, that filtration and ordinary boiling in the evaporators are not sufficient (in one case out of ten) to produce a syrup that will crystallize as it should.

Filtration of cold cane-juice, therefore, only places it in a more favourable position for clarification; for although it may remove from the juice any substances that are suspended in it, yet it by no means frees it of those that are *dissolved* in it.

My belief, then, is, that the filtration of cold juice is not such a highly important desideratum; as the principle of non-employment of heat cannot be carried out entirely in the process of clarification. For instance, we will take cane-juice that has been carefully filtered, and endeavour to render it into a solution of sugar and water alone, by depriving it of the gummy and glutinous matters dissolved in it. Proceeding, then, on the belief that these matters are held dissolved by some disguised acid, we treat the filtered juice with lime, in order to saturate the acid and restore to the gummy and albuminous matters their insolubility; which thereon will present themselves in the form of a flaky coagula, showing a disposition to precipitate. But is the action of lime so applied confined merely to the saturation of this free acid? No! far from it: its beneficial action extends to the expulsion of the nitrogen contained in the glutinous matter, and its own combination with the acid which formed the base of the ammoniacal salt.

It has been proved, by Liebig, that the juice of maple and birch trees, and beet-root, contains an ammoniacal salt, which, on evaporation, or saturation by lime, gives off ammonia in considerable quantities; whilst the neutral salt is converted, by the loss of ammonia, into an acid salt, which, under the former circumstances, combines with the sugar, converting it into *glucose* or uncrystallizable syrup; and, under the latter, combines with the lime.

It has also been abundantly shown by Raspail, Liebig, and others, that gluten, or vegetable albumen, contains nitrogen in the form of an ammoniacal salt, which is decomposed, and its ammonia expelled, either by evaporation (by heat) or saturating the acid base with an alkali (lime).

The action of lime, then, on the filtered cane-juice is twofold, viz., to saturate the acid base of the ammoniacal salt contained in the gluten expelling the ammonia; and to saturate the free acid which holds the gluten, or albumen dissolved, thereby causing the coagulation and precipitation of that substance. The quantity necessary for this object might be readily determined by any careful person, as the clear filtered juice will, on the gradual addition of lime, present marked signs of a coagulation of its gluten taking place:

which may the more readily be discovered by viewing a little of the juice in a wine-glass, tumbler, or decanter.

But, that the process of filtration may proceed* without subjecting the cane-juice to the liability of fermentation, it is necessary that the juice be united with sulphurous acid; which would be one more acid that the lime would have to combine with and precipitate. On the whole, therefore, there does not appear to be any extraordinary advantages attending this process; whilst the trouble attendant on it, and the risks incurred, are sufficient to warrant its rejection.

I have merely bestowed a passing notice on the filtration of cold raw juice through bag filters, as it has been so much dwelt upon by many writers of essays; but the observations I have been led to make relative to the ammoniacal salt contained in gluten, and the free acid which holds the gluten dissolved, as well as the action of lime in both instances, strictly apply throughout to the subject of defecation.

I will now proceed to consider the better modes of defecating cane-juice, as deduced from practical experience and chemical experiment; and shall endeavour to treat the subject as concisely as possible.

1. *Defecation, as now practised on several estates.*—Two filtering boxes, each of about three feet square and four feet deep, with a division in the centre running from the top of the box to within an inch or an inch and half of the bottom, are filled by layers of pebbles, coarse gravel, coarse sand, and very fine sand; then coarse sand, coarse gravel, and pebbles; that is, four layers in rotation in each division, commencing with pebbles, and finishing with them; so that in both divisions the pebbles are uppermost, and the fine sand is at the bottom, one foot deep in each division.

A piece of basket-work lies on the top of the pebbles of the receiving division, whilst the discharging division has none.

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* It is tolerably certain that raw cane-juice will take twice or thrice the time to filter, thoroughly, that partially clarified cane-liquor will.

The cane-juice, in coming from the mill, passes through two or three wire-gauze strainers (as is usual), then flows into the basket-work, descends through the four strata in the one division of the filter, and rises up through the other in like manner; being discharged, by means of a lip, into the clarifier. When one clarifier is filled, the juice gutter is moved on to the second filter, which is already prepared and fixed over the empty clarifier. The first filter is then pushed along a slide to the cleansing tub, when the whole of the contents are taken out—each strata separately—and washed. To facilitate this, a piece of fine matting or coarse cloth is laid over each strata, as it is placed in the filter, so that in emptying it, no difficulty occurs in separating the several layers; which are accordingly well washed and immediately returned to the filter; the water wherein they are washed being upset in the skimmings-gutter, passes into the distil-house. Whilst the gravel, sand, &c. are being washed, the filter is also washed down quite clean, and then washed with lime-water, to prevent anything like acidity.

One man will empty the filter, cleanse the whole affair thoroughly, and return it to its place, all nicely packed again, in a quarter of an hour; so that it is ready for use long before it is required.

When in the clarifier, heat is applied, until the liquor has attained a temperature of about 150° Fahrenheit, then about ¾ lb. of temper lime is added to a 450-gallon vessel in the form of cream of lime (by the addition of water), and the whole is well stirred up until the lime is supposed to be well blended with the liquor. The heat is then allowed to go up to about 180° to 200°, which raises a thick scum, that after a while hardens at the top and cracks; whereon the fire is withdrawn, and the liquor allowed time to precipitate: say from 15 to 30 minutes.

The cock is then turned, and (the first quart or two being caught in a pail and thrown back into one of the other clarifiers) the clarified liquor runs into a filter, made on the same principle as the former ones, but filled with fine-grained (coarsely-powdered) vegetable charcoal. In this case, the filter is provided with very fine wire-gauze on the top of both its divisions, so that the pieces of charcoal cannot rise; but the liquor passes down one division and rises up the other freely, running direct into the grand copper (first evaporator). This filtration occupies but a very short space of time, and from the matter retained by the charcoal, shews how beneficial it must be. One filter is used to run off about 1000 gallons of liquor; it is then removed to be cleansed, and the second filter takes its place: thus there are four filters in this system, or rather two pair; one for the cold, raw juice, and the other for the clarified liquor.

The *defecation*, properly so called, ends here: but in the first evaporator more alkali (lime-water) is added, sometimes a considerable quantity, not all at once, but at intervals; and again in the second and third evaporators, and the second tache, lime-water is added, from a watering pot; which in the case of the second tache is sometimes varied, by giving a saccharate of lime (lime mixed with thin syrup, and allowed to precipitate, the liquor forming the saccharate).

The usual skimming, of course, takes place during evaporation; and when concentrated, the syrup is run off, by means of a large discharge valve, into coolers or (unheated) granulators; every second skip being mixed together to induce the formation of a large grain.

Remarks.—In this system, the filtration of the raw juice and that of the partially clarified liquor is attended with very decided results: I have seen the liquor passing from the charcoal filter into the first evaporator in a highly clarified state; which could not be the case were temper lime not used in the clarifier. The small quantity of lime used in the clarifier is added when the temperature of the liquid reaches 150°; because at about 140° to 150° the coagulation of the gummy and albuminous matters commences, and the acid which held them in solution is set free: also because the acid forming the base of the ammoniacal salt contained in the glutinous matters is disengaged by the loss of ammonia; both which acids would immediately attack the sugar, and render a portion of it uncrystallizable. At this juncture the lime comes into play; one portion of it immediately saturating these disengaged acids, and the other, those not disengaged: that is, those still in combination with the dissolved gluten and the ammonia.

In this manner, the clarification can be conducted at a temperature of not higher than 180° Fahrenheit, which is seldom exceeded; this moderate heat,* in conjunction with the alkali, being considered much more safe and efficacious than a far greater heat, unaided by the alkali.

The after course pursued in the evaporators, is simple and judicious: it is quite impossible to lay down as a fixed rule what quantity of lime ought to be used, as it depends so greatly on the quality of the juice in the first instance; but the greatest range that I have known in boiling-houses, pursuing the above system, is from ¾ lb. to 2¼ lbs. in 450 gallons, including its treatment in the clarifiers and evaporators.

The filters are of common wood, and are made on the estates, at a cost of about five or six shillings each.

2. *Defecation by means of heat in the clarifier, and heat and lime in the precipitator.*—According to this plan, each clarifier has a precipitator of similar dimensions, hung on a lower level, so that the contents of the former can be drawn down into the latter.

The clarifiers are so arranged that they can be heated by the heated air from the evaporating ranges, or by their own fire, as may be desired; the precipitators, on the other hand, are heated solely by their own fires, and have therefore no connection with the flues of the boiler ranges. The cane-juice in coming from the mill to the clarifier, passes through three strainers of different degrees of fineness, which deprives it of its grosser particles. The fire is then allowed to act on the vessel until the temperature of the juice reaches from 180° to 210°, at which it is kept until a thick crust of scum has accumulated at the top, and it begins to crack, discovering small pearly-white bubbles rising in the cracks. The fire is then withdrawn, fifteen or twenty minutes is allowed for the heavier bodies floating in the liquor to precipitate, and the partially clarified liquor is carefully run off into the precipitator.

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* Sometimes the liquor will clarify at 165° Fahrenheit.

Here the fire is urged until the liquor boils, during which time a man stands by with a measure of strong lime-water, and a scummer; a portion of the former he adds every now and then, stirring it well into the liquor, then waiting each time to skim off any scum that rises. In this manner he keeps adding the alkali and skimming the liquor, until very little scum rises, when he examines a little liquor in a wine-glass; and if he discovers the signs of flocculi floating in it, and finds, both by taste and smell, that sufficient lime has been given, he withdraws the fire immediately and completely, and allows the liquor time to precipitate. This time is seldom more than one hour, or one hour and a quarter; when it is drawn down into the evaporators, and goes through the usual routine of boiling to concentration; a little lime-water, or saccharate of lime, being added, if occasion be seen.

Remarks.—In this method, the lime is not given in the clarifier, to avoid the effect it is said to have on the colouring matter contained in the juice; and its gradual addition in the precipitator is to saturate the acids, as before described, and to assist the temperature employed in effecting the complete coagulation of the albuminous matter. The palpable mistake is, however, in supposing that the flocculent particles floating in the liquor will precipitate in so short a time; for I think it no exaggeration in saying, that six hours are requisite for such boiling liquor to cool down and precipitate its flocculi. It therefore occurs, that, as the time allowed is much too short for precipitation, the unprecipitated flocculi will pass into the evaporators, and become part and parcel of the concentrated syrup, when it leaves the tache for the coolers. The simple addition of the wood charcoal filters, mentioned as used in the preceding system, would render this method infinitely more complete than it can be without them; and it is one so easily made, that no doubt it will be adopted.

Many systems similar to these are now in practice; each, however, varying somewhat from the other. As to the old and extremely censurable plan of running liquor from the clarifiers into the evaporators just as it is wanted, without reference to its being clarified or not, I cannot characterize it as being other than a disgraceful neglect, and a wilful injury to the estate whereon it is permitted.

Next to this shameful practice, is the common mode of clarifying in the clarifier, and then drawing down the liquor into the evaporators *direct;* without further care being taken to separate the glutinous matter held dissolved, or suspended in the liquor, by means of filtration or subsidence. These are two very simple remedies, either of which can be availed of, without any but the most paltry outlay; as I have already shown in the case of filtration through wood charcoal filters.

I would wish to impress on the planter, in the strongest possible manner, that the operations in the boiling-house should tend to the accomplishment of two great objects; viz., the complete separation of all extraneous matter from the cane-juice, so as to bring it, as nearly as possible, to the state of sugar and water alone; and secondly, the evaporation of the surplus water, so as to leave the sugar in the condition of a fine white syrup, which will crystallize wholly and well.

The first is to be accomplished by means of defecation; the second, by means of evaporation and concentration; and it only rests with the planter, whether or not he will pursue those methods which will enable him to carry out these objects effectually and successfully.

I will now point out the means whereby defecation the most complete can be effected.

3. *Defecation by the application of finings, as patented by the Honourable E. C. Howard, in* 1812.—The cane-juice running from the mill is made to pass through four brass-wire strainers; the first and second being coarse, the third fine

wire-gauze, and the fourth very fine ditto. These deprive it of a large portion of those substances mechanically suspended in it; therefore, the juice arrives in the clarifier much more clean than it otherwise would. As soon as the bottom of the pan is covered, a gentle fire is applied under it, so that by the time the pan is filled, the whole body of the liquor is warm. Then take two ounces of (finely sieved) quick-lime to each hundred gallons of juice to be operated on; mix it with clean water, into a cream of lime, and add it to the juice, taking care to mix all well together. The temperature may now be allowed to rise to 180° Fahr.; and it must be kept at that, until a thick crust rises on the surface of the liquor, and exhibits a disposition to crack. This may take from fifteen to twenty minutes, from after the lime has been applied; but, if the scum does not rise and crust as desired, the fire may be urged further until it does so; taking care not to exceed 200°, or, indeed, to go higher than is absolutely necessary.

The thick crust having risen and shown symptoms of cracking, the fire is stopped; and, in ten minutes after, the liquor is drawn down through a very fine wire-gauze strainer, into the second defecator (which I have called a precipitator, as it is known under that name in Demerara and the West India Islands, although it is a misnomer) or precipitator.

The fire is here made sufficiently strong to bring the liquor to a temperature of 210°, or as much higher as can be without suffering it to boil. Whilst this heat is maintained, a man stands by with a scummer, and skims off, very quickly and carefully, all the scum that rises, until he has cleared it all off. Then the liquor may be permitted to boil, the skimming continuing about ten minutes, or a quarter of an hour; the scummer is then laid aside, and Howard's finings are applied (*see note*). The finings are well mixed

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Note.—These finings are prepared by slacking well-burnt lime with boiling water, so as to obtain a cream of lime; to this is added an equal bulk of water, up with the liquor, and the boiling is allowed to continue for about two or three minutes longer, when the whole is well stirred up, and immediately run off into a fining cistern, where it is allowed to subside during four or six hours. The clarified liquor is next drawn off through the common wood-charcoal filters (before spoken of) into the evaporators, by which time it will have become cool, but beautifully clarified.

If the fining cisterns are objected to, then, instead of having them, the liquor is allowed to remain in the precipitator for two hours after the fire is withdrawn—that subsidence (at least in part) may take place—and is finally drawn off through the charcoal-filter into the evaporators. The two hours allowed for subsidence in the precipitator is a very inadequate time; but even that space would inconvenience

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and the mixture is boiled for some minutes, until the lime assumes the appearance of fine curd; the extraneous matter is then washed away, and the lime and liquor are run through a fine sieve. The next part of the process is, to dissolve, in 6 gallons of water, about 2½ lbs. of alum for every cwt. of solid sugar (say 100 gallons of cane-liquor) that is to be refined, adding to such solution about 3 oz. of whiting (purified chalk) for each 2½ lbs. of alum; the mixture being stirred until effervescence ceases. It is then allowed to subside, and the solution (containing sulphate of potash, which is very injurious to sugar) is drawn off from the precipitated matters (which are alumina and sulphate of lime). After this, the precipitate is put with the prepared lime-curds, and shaken up with the water they retain; the whole being agitated during the effusion: the curds are to be in such proportion, that paper stained with turmeric shall barely change its colour by immersion in the mixture, and shall recover its former yellowness when dry.

The finings, being thus carefully prepared, are suffered to settle to the bottom of the vessels they are contained in; and, after draining off the supernatent liquor, the finings are placed upon blankets, supported in the manner of a filter, and the moisture is drained off, until the mass begins to contract, and cracks on its surface; the finings are then fit for the clarification of the sugar (or cane-liquor). Add the solution of sugar (or cane-liquor) to them in such a proportion as will bring it to a creamy state, and then pour the whole and mix it equally into the sugar (or cane-liquor) to be fined. The clarified sugar (or cane-liquor) is suffered to remain for several hours before the bright liquor is drawn off from the finings (see Howard's patent, 1812).

Remark.—Any one of the commonest intelligence can make these finings, without any difficulty whatever. They are commonly used in refineries, both in France and England, and are found to answer well.

very much the operations, as before that time had elapsed the precipitator would be again required for a fresh operation.

It is very true that one hour only might be allowed; but it must be remembered that far more work would be required of the filters in that case, and the liquor would not be so well clarified.

The matter then resolves itself into a question of cost and time, which I consider may very satisfactorily be solved as follows:—

With a mill delivering 1000 gallons of juice in one hour, two clarifiers, and two precipitators, or second defecators, of 500 gallons each, would be required, together with eight fining-cisterns of the same dimensions: a saving of three iron defecators of 500 gallons each, at 30*l.* each £90 0 0

Less cost of eight cisterns, made of fine hard wood, 6 ft. square, and 2½ ft. deep, at 2*l.* each	£16	0	0			
Less cost of eight large cocks for the cisterns, at 1*l.*	8	0	0			
				24	0	0
Actual saving by the exchange . .				£66	0	0

I have here estimated the cisterns as costing 3*l.* each, with cocks; but in the East they will not be so much, whilst in the West they can scarcely be more. Next we come to the working time.

4 o'clock Monday morning.—The mill started, and first clarifier filled in half an hour.

5 o'clock.—Contents of first clarifier enter the precipitator, partially clarified.

5½ o'clock.—The above liquor having been treated with finings, enters the fining cistern.

9½ o'clock.—The same liquor passes through the filter into the evaporators, highly clarified.

10 o'clock.—The second 500 gallons, in like manner, enters the evaporators, and fire is called.

10½ o'clock.—The third 500 gallons also enters, making 1500 gallons received in one range.

11½ o'clock.—1000 gallons of juice so clarified have been received in second range, and fire called.

12 o'clock.—1500 gallons have been received in second range, therefore both ranges are full.

Thus by twelve o'clock (noon) both ranges are full, and boiling away as fast as good fires can make them; each range receiving a supply of 500 gallons of highly clarified juice every hour.

At four o'clock in the afternoon the mill, having supplied 12,000 gallons of juice, stops; is washed down, and the mill gang are dismissed.

At nine o'clock, that quantity of liquor will have been received in the evaporators; and, allowing half an hour for boiling the last liquor received, cleansing cisterns, filters, &c., and attending to the last skips struck, we find that by half-past nine o'clock at night, work will have ceased, and the boiling-house be locked up for the night.

The next morning the mill again starts at four o'clock, and fire is called in the boiling-house at eight o'clock, so as to be ready to receive the first 500 gallons of fresh liquor at half-past nine o'clock.

At four o'clock P. M. the mills stops as before, and the boiling-house closes at half-past nine o'clock, P. M.; and so on until the end of the week.

If half-past nine o'clock be considered too late an hour, nothing can be more easy than to abridge it two hours (making the hour for closing half-past seven o'clock), by returning, by means of the montejus, the last 2000 gallons of liquor into the clean defecators (as it runs from the filters), where it would remain without the least liability to injury, until the next morning. Fire would, under these circumstances, be called at six o'clock in the morning instead of at eight; and as the defecators are required for use, the clarified liquor contained in them would be run off into four of the eight fining cisterns, merely as an accommodation, until the evaporators could make room for it. If the engine stops, and the fire under the steam boiler be withdrawn at four o'clock, (when the mill stops work,) of course the montejus could not be used in the case stated, as there would be no steam available to work it; therefore the liquor would be elevated by manual labour. But it might possibly happen, where a vacuum pan or Wetzal's concentrators are employed, that it would be found convenient to keep these going until seven o'clock in the evening.

There can be no doubt of the highly efficient means of separating all impurities from the cane-juice and liquor, offered by the foregoing plan; whilst there is nothing in its working detail but what is simple and practically convenient.

In giving this plan, I have purposely made it to apply to the cane-liquor before it reach the evaporators; as it appears to me very desirable that the liquor should be so purified as to be, as nearly as possible, a mere solution of sugar and water, ere it be subjected to the evaporating process. The above plan, however, admits of a variation, which would render it somewhat of a combination of Howard's and Dutrone's principles.

This variation consists in defecating the liquor, as I have stated, in the clarifier and precipitator: only using a very slight quantity more of lime in the latter, and no finings; then drawing the fine liquor off through a wood charcoal-filter into the evaporators, where it is boiled down to a density of about twenty-four or twenty-six degrees by Baume's saccharometer, and is next discharged into the montejus; which raises it into the fining-cisterns, where it is mixed with the finings, as before laid down, and the liquor allowed to precipitate until the next morning. For instance, the mill starts at four A. M.; the first boiler range calls fire at six A. M.; the mill stops at four P. M.; and the boiling ranges draw fire at six P. M.; when the whole of the liquor that had been concentrated (up to that time) to the density above mentioned, would be in the fining-cisterns, where it would remain to precipitate the whole night. The next morning, directly the engine commenced work, so would the concentrating apparatus (whether the vacuum pan or Wetzal's pan), and the whole day it would be employed in concentrating that syrup which had been fined the night previous; and so each day it would continue in the same routine. Supposing clarified cane-liquor when it enters the evaporators to be four-fifths water and one-fifth solid matter, and that this liquor is boiled down to a density of 27° Baume, then we may reckon the quantity of syrup which would be received into the fining-cisterns at about 4320 galls. out of the 12,000 gallons of juice received from the mill; requiring, therefore, (say) nine fining-cisterns of 500 gallons each to contain it.

The accuracy of Dutrone's opinions in regard to the treatment of cane-juice are, singularly enough, being recognised at present by every writer on the subject: the lapse of time since he wrote, has not, however, changed the nature of those prejudices which militated against the adoption of his views; so that we find ourselves compelled to go over the same ground he did, and to enforce the same arguments that he held: at least as far as separating the impurities of the liquor go.

His recommendation of subsidence in reservoirs during ten or twelve hours, has been constantly scouted by planters, on the grounds of the plan being attended with a greatly increased consumption of fuel, and giving so much trouble. I have very carefully weighed these objections, and, as far as increased consumption of fuel is concerned, it is quite evident that its extent is not one-third so great as it is declared to be; but in regard to the second objection, I need not say more than that it is a well-known and dearly cherished excuse of "the old school" planter, when he does not wish to enter on any improvements—"Oh, it gives too much trouble!"

In these times, however, such excuses must give way, and the planting interest must have fair play, otherwise it never can bear up against the changes time has brought with it.

Dutrone's method was, first, defecation in the clarifiers; then, boiling, attended with skimming and cleaning in the evaporators, as is usual, until the liquor had become syrup of a density of about 22° or 24° Baume's saccharometer, when it was run off into reservoirs, where it was allowed to precipitate during twelve hours; so that the impurities were very completely separated from the syrup. The hot syrup of course gets cold during twelve hours time, and to heat it again to the same temperature, requires an amount of fuel which has formed so prominent an objection to the pursuance of this plan. But it does not seem to have occurred to any one, how easily the major part of this objection may be removed. During, we will say, Monday's boiling, all the syrup brought to a density of 24° Baume, is forwarded to the reservoir in order to precipitate until next morning; and during Tuesday, the tache undertakes the concentration of the syrup of the day before; consequently, in starting, the tache is filled with this syrup, and the operations commence. As the *tache* has to concentrate the syrup of the day before, the *second tache* has to bring the (present) day's liquor to a density of 24°, in order to settle as the other did; therefore, when the second tache discharges a skip of boiling syrup, instead of allowing it to run into the reservoir direct, that skip is received into a double vessel, and gives out its heat to the cold syrup which surrounds it, viz. to the syrup of the day before. This vessel is situate between the taches and the precipitating reservoirs, and is formed by having one vessel within another; the inner being wholly covered by the liquid contained in the outer, and provided with a small air pipe rising from its centre; as well as having two pipes, one to charge, and the other to discharge the vessel.

Now in commencing operations on Tuesday morning (and constantly during the day), the outer vessel is filled with the cold syrup from the reservoirs, so as to cover entirely the inner vessel; then the various skips of syrup (of a density 24°) discharged from the second tache, enter the inner vessel, and each remain there, until another is about to follow, when it is run off into the clean reservoir, and the other hot skip takes its place.* By this most simple arrangement, it will be perceived that each skip of hot syrup imparts its heat to the cold syrup which surrounds it, and consequently that the syrup from the reservoirs enters the tache, heated to a high degree instead of being cold. Thus we see that certainly two-thirds of the heat of the syrup intended for the reservoirs is economised, instead of being lost.

It is a mere question as to whether subsidence (precipitation) or filtration is the more economical and effectual: for the latter, bag-filters are used in the refineries in England with very great success; I shall therefore speak of them as I proceed.

4. *Defecation by means of sulphate of alumina* is best pursued by the addition of lime, prior to its being applied to the liquor: for instance, every 100 gallons of cane-juice to be acted on, will take 1 lb. (or rather more) of sulphate of alumina, which must be first dissolved in water, then treated with 12 ounces of caustic lime, which will decompose the sulphate; the acid combining with a portion of the lime, forming sulphate of lime, another portion combining with the alumina, and a third portion remaining as a free agent. Applied in this state to cane-liquor which has been partially clarified, the alumina immediately combines with the colouring matter, and the sulphate of lime and lime with the other organic matter, precipitating them, without causing any injury to the cane-juice. Thus, three defecating substances of very great power, may very safely, and very beneficially be applied; and it will be found that

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* There should be two of these compound vessels; the hot syrup giving half of its heat in the *one*, and half of the remaining portion in the *other*.

none can more completely meet the planter's views than these substances combined. When these are to be used, they had better be applied in the precipitator; immediately after, bring the liquor to the boiling point for three or four minutes, then draw the fire, and after allowing a little time for subsidence, pass the liquor through a filter, and evaporate.

Pure alumina, sulphate of lime (gypsum), and lime, is but another way of arriving at the same combination. Indeed, these are in the end the same kind of substances as those first patented and used by Howard; they may be presented under different forms and names, but after all, they are comprised of three substances only, viz., alumina, sulphuric acid, and lime.

Sulphate of alumina is procured by expelling the potash, or ammonia from alum* by means of lime; or pure alumina derived from clays (such, for instance, as the Kaolin clay of Cornwall, which, according to Wedgewood, contains 60 per cent. of that oxide) is treated with sulphuric acid, thus forming sulphate of alumina.

There are no defecating substances with which chemistry is at present acquainted, that are so powerful, so safe, so simple, and so cheap, as the three combined, — alumina, sulphate of lime and lime; and it is somewhat singular that though we have to go back to the year 1812 for this discovery (by Howard), yet it has, I may say, never to this day, been used in the colonies; where the greatest good would have resulted had it been adopted.†

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* Alum itself will not answer for defecation because of the potash (or ammonia) it contains. Alum is made, sometimes with potash, sometimes with ammonia.

† In 1816, Mon. Dorion, of Martinique, proposed to clarify cane-juice by means of the bark of the Treabroma gazuma, or wild elm, instead of using the blood of cattle. Whatever its particular merits are, I never have been able to ascertain; but Mon. Blachette informs us that it was considered of so much importance that the Colony (Martinique), after many satisfactory experiments, presented Mon. Dorion with 120,000 francs, to which Guadaloupe added a similar sum, and the English Colonies even more. He also says, "that the discovery was ascribed to a Mon. Duchamp Delbecq;" but he altogether omits to inform us in what way it was so important.

Common potash alum sells in England at about 6*l.* per ton at the alum works, and could, no doubt, be delivered in any quantity in the East or West Indies at 9*l.* per ton, including all charges. Very great abundance of sulphate of alumina is manufactured in France, where it is used in the defecation of beet-root juice; and an order sent to any of our alum works, either in England or Scotland, would procure as much as can be needed; and at a price much below that of alum, as the sulphate of potash contained in the latter would not be required.

But taking common alum at 9*l.* per ton, delivered in the colony, we may here inquire what the clarification of cane-liquor would cost, reckoning, according to the old method, one gallon of juice as yielding one pound of sugar: 2,500 lbs. of alum, at 2½ lbs. to 100 gallons of liquor, equal to 100,000 gallons of liquor; 100,000 gallons of liquor will yield forty-nine tons of sugar, costing for alum about 10*l.*, or about four shillings to each ton of sugar made.

Sometimes clay is met with so pure, that, by being burnt and pounded, it becomes a very efficient defecating substance; especially when mixed with sulphate of lime (gypsum) and lime.

5. *The System of Defecation particularly recommended for practice on estates.*—In coming from the mill, the juice is made to pass through four strainers of increasing degrees of fineness, the last being very fine, (as before stated, page 353), before it falls into the clarifier, which I 'll suppose to contain 500 gallons. Directly the bottom of the pan is covered, heat is applied under it; by which the heating and

In Jamaica, there is a very common tree, named the "Bass-cedar," which bears a fruit (if it may be so called) about the size of a large nutmeg, of a black colour when ripe, sweet to the taste, and extremely slimy when chewed. I used to feed my horses on them, and have often chewed a portion of one myself, when I have been struck with the large quantity of slimy matter they afford. Since then, I have frequently thought that they might be availed of for clarification, by being bruised and soaked in warm water, to make them give out their glutinous matter. Perhaps this may serve as a hint to those who are on the spot, and who have every opportunity for trying how far they be made useful in this way.

filling go on simultaneously, so that by the time the pan is filled, the juice is pretty hot. Then take about ten ounces of fine-sieved quick-lime and mix it with clean water, so as to form a cream of lime, which add to the juice in the clarifier; taking care to stir it up well, so as to make the alkali diffuse itself evenly throughout the whole body of the liquid. The temperature may now be allowed to rise to 180 degrees Fahr., at which keep it for some time, to see if the scum rises in a desirable manner; but if it does not, raise the temperature by degrees until it does; but on no account allow it to rise above 200 degrees Fahr. A thick scum having risen and formed a crust, symptoms will speedily appear of a disposition to crack; on which the fire may be withdrawn entirely; the time, from the pan being quite filled until the fire is withdrawn, being usually about fifteen or twenty minutes. Ten minutes is now allowed for the liquor to settle a little, when it is to be drawn down through a very fine wire-gauze strainer into the precipitator, taking care that none of the sediment accompanies it; to prevent which, the bottom liquor, more or less mixed up with the sediment, had better be drawn off carefully by itself, and thrown into the clarifier then filling. Immediately the partially clarified liquor enters the precipitator, a brisk fire is made until the temperature of the liquor rises to 210 degrees, at which keep it a few moments, whilst a man with a scummer skims off whatever scum may arise. When no more appears, raise the temperature to the boiling point, skimming it carefully for about ten minutes; then add to it the defecating menstruum made in the following manner,—three* pounds of sulphate of alumina is dissolved in three gallons of water, to which solution twelve ounces of lime is applied, and the whole well stirred until the decomposition is complete; then add four ounces more of lime, mix all well together, and allow time for precipitation. When this is complete, run off the supernatant water, and the precipitated matters will then be, alumina, sulphate of lime, and free lime. Add to these a little clean water, sufficient to bring the whole into a creamy state, and it is then ready for use.

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* If the liquor be very foul, five or even six lbs. may be used; the lime being in proportion.

When this is added to the liquor in the precipitator, it must be thoroughly mixed up by stirring, after which, the boiling must be kept up for about three or four minutes; the fire is then withdrawn, and the liquor is ready to be drawn off, either into the filters or fining cisterns. It would be useless to keep it longer in the precipitator, as none but the grosser particles will subside for a length of time; therefore we must trust either to filtration, or to subsidence in the fining cisterns, as I before described.

If filtration be preferred, two rum puncheons well packed with moistened wood charcoal (the one leading by pipe to the other) may be used with economy and advantage; but if bag-filters* are thought preferable, they may be employed instead of the former. Whichever may be chosen, however, care must be taken to keep them perfectly clean and sweet; and this constant washing and thorough cleansing appear to me to constitute the only disadvantage of the system of filtration, whereas, in using fining cisterns, nothing of that kind can be urged. But as 500 gallons of juice can be supplied by the mill, be clarified, defecated, and filtered in about two or two and a half hours, whereas the same quantity would take five and a half hours, if subsidence in the fining cisterns were substituted for filtration, I will premise, therefore, that *filters* be used, and that the first 500 gallons of filtered liquor enters the evaporators, within two and a half hours after the mill commences work in the morning.

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* Bag-filters consist of a number of strong twilled cotton or calico bags about sixteen inches wide and six feet long, each of which are inserted in another bag (made of canvass) of only six inches wide, but bottomless. The upper part of the two bags is tied tightly on to a short metal tube which thus becomes the neck of the bag, and it is then fitted into its appropriate place in the frame-work of the filter, by means of a screw which keeps it firm and tight. The upper portion of the filter forms a cistern; which should be capable of containing the same quantity as the precipitator.

Each filter should comprise twenty or thirty bags; and the filtration will then proceed very rapidly. Filters of this kind can be very easily made on every estate, and cannot cost more than from 5*l.* to 6*l.* each, even in the West Indies. There must always be *two* of these wherever they are used.

Liquor which has undergone the clarification and filtration above described, must be in a very pure condition when it reaches the evaporators, and will consequently require little or no skimming during evaporation; nor will it require any further application of lime; although for the entire satisfaction of the planter it may be tested with litmus paper, both when it first arrives in the evaporators, and also when it reaches the third evaporator.

It must altogether rest with the planter himself, as to what description of evaporating vessels he will use: but to pursue the course of manufacture I am describing, I will, as a medium, take a "range" such as those of Messrs. Blyth, Plate XIV., open pans worked by a naked fire. In evaporating the liquor, the greatest care must be taken to keep the pans filled, much above the parts on which the fire strikes, so as to prevent any burning; if this be neglected, as it too often is, a caramelization takes place from the burning of the sugar, and the colour is proportionally heightened. It is from this liability that I so much prefer flat or slightly convex bottom pans. The filtered liquor of which we are now treating should be extremely clear, and with little or no colour; so that, if care be taken to keep the pans properly filled, little or no accession of colour will be caused by the heat it receives in the evaporating range, up to a density of 28° by Baume's saccharometer. Arrived at this density (say fifty parts sugar and fifty parts water), it should be drawn off (skip by skip), and will then present itself in the form of an exceedingly fair syrup. It is now to be decided as to whether this syrup is to be passed through the animal charcoal filters or not; but as I should suppose that no planter can be so negligent of his own or his employer's interest, as to demur to that process, after the facts I have stated (in the foregoing chapter), I will premise, as a matter of course, that the important action of animal charcoal is had recourse to. The syrup then, as it leaves the evaporating range, runs into a receiver; to which a montejus is attached, and is thereby elevated to the charcoal filters. Having passed through the animal charcoal, the syrup is found to be greatly purified and much whitened. It next is placed in the vacuum pan for concentration, after which it is drawn off into the granulators; to which steam is applied to keep up a temperature of about 180 degrees Fahr., in order to promote the granulation of the concentrated syrup.

From the granulators the new sugar is taken into the curing-house, where its perfect crystallization and ultimate curing takes place. There can be no doubt that sugar so made would be fully equal, if not much superior, to our single refined lump sugar. The planter would have a fine white strong-grained sugar, which would command a high price anywhere. It would be a sugar for the *grocer*, not the *refiner;* and, in short, it would be that description of sugar which would pay the planter better than any other; and on which there could be no loss by wastage, drainage, &c. &c.

However, to go back to the consideration of the evaporating pans, I believe there can be no question as to the complete superiority of the steam-heated pans over those worked by a naked fire: in fact, the advantages are so numerous, that I would never have other than steam pans for my own use, if I possibly could avoid it. The consumption of fuel is somewhat greater, but the great facility it offers for using wood and coal as fuel, instead of cane-trash, and the ready manner in which the temperature to each pan can be regulated, and in an instant stopped or renewed, far counterbalance the small amount of extra fuel required. Besides, in many places fuel is in such abundance, that its increased consumption is a matter of no importance whatever. Even our West India colonies, which can have excellent coal laid down at 1*l.* per ton, certainly have no occasion to exclaim against steam evaporators on the score of fuel.

I have, however, in the foregoing plan, preferred mentioning open pans worked by naked fires, as I know that they are so generally used; and I must here observe, that well-defecated cane-liquor, if carefully attended to, runs no risk of burning or increasing its colour during *evaporation* in open pans over a naked fire; for it is during the *concentration* that the injury is done! The experiments of Mon. Soubieran and others, have completely established the fact, that syrups may be evaporated in common open pans, until they contain three parts (lbs.) sugar to one part (lb.) of water, without receiving any injury from burning, or any increase of colour; provided that the vessels be properly filled, and the evaporation proceed quickly.

But an evaporation beyond that point, produces a visible effect on the colour of the syrup, from the decomposition taking place in the sugar; which is rendered uncrystallizable, or what is termed *glucose*.

Hence we see that we may evaporate our syrup until it contains only one part water, to three parts sugar, in open pans; but to avoid all risks from burning, I would always choose flat, or slightly convex (arched inwards) bottom pans, with no brickwork at the sides, in order to prevent the glowing bricks from communicating too much heat in those parts. Having brought our syrup to this density, our next care is to concentrate it (*id est*, to evaporate as much of the remaining one-third water as possible), without entailing a greater loss than is absolutely unavoidable. Thus, when animal charcoal is *not* to be used, the well-clarified and finely-filtered cane-liquor may be evaporated up to, say 230° Fahr. at once; then discharged from the tache in order to be concentrated. I may mention three methods of accomplishing this object, two of which are in common use.

The *first* is the vacuum pan; the *second* Wetzal's pan, or Gadesden's, and the *third* a modification of Godfrey Kneller's process. The vacuum pan is the most complete method now practised, as by it, syrup can be concentrated at as low a temperature as from 160° to 180° Fahr., which insures it from injury. Wetzal's pan is a much cheaper method, whilst it admits of the temperature being kept equally low.

I have often seen syrup concentrated in such pans at from 160° to 165°; but extremely simple and useful as they are, yet I consider that the constant beating (if I may so term it) the syrup receives from the revolving wheel, to a certain degree, injures the formation of the grain: although this observation applies chiefly where the evaporation is carried very far.

Kneller's plan was to force cold air through the body of the syrup; but by sundry improvements introduced by M. Brame Chevallier, it has been rendered much more perfect. By the improved method, the vessel is provided with a steam jacket, a coil of piping inside, and a set of tubes; through which last, dry air is forced to the bottom of the pan, and rising through the body of the liquid carries off a large amount of vapour, at the same time keeping the liquid at an extremely low temperature. Sugar made in such pans has completely rivalled that of the vacuum-pan in every respect; but from the fact of the vacuum-pan being found to be so well adapted to the purposes for which it is required in refineries in Europe, the use of the improved Kneller's pan has not been encouraged. I am not, however, in any way convinced that it cannot be employed to very great advantage on sugar estates: on the contrary, I am satisfied that it may.

My reasons for entertaining this opinion are, that the cost of a pan capable of containing 200 gallons of concentrated syrup, together with its steam jacket, steam coil, and air tubes complete, would not be more than 80*l.*: the air-pump* would not cost more than 25*l.*; the extra power of the mill-engine would be more than sufficient to work it; and lastly, the facilities for obtaining dry air on a sugar estate are very great: as in very hot, dry weather, the common atmospheric air would answer admirably; whereas, in damp weather, it might be easily dried without incurring other than the most paltry expense.

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* A double-actioned air-pump of 12 inches diameter, and 18 inches stroke, will deliver about 100 cubic feet of air per minute; which, if properly dried, would evaporate heated syrup *faster* than the vacuum-pan, and at an equally low temperature. A pump of this size would take 4 horse-power from the engine to work it, and would cost 30*l.*

A pan of this character would work infinitely faster than a Wetzal; and, if the air were dry, fully as fast a vacuum-pan; or faster. I calculate that a pan of about the size I have named, is capable of turning out upwards of twelve tons of sugar a day, from syrup comprised of three parts sugar to one part water. I cannot recommend this pan too strongly. I do not think that planters have yet given this particular description of concentrator as fair a trial as it should have; or such as their own interests seem to demand.

It is common with sugar-boilers using either of the low temperature apparatuses to concentrate their syrups far too high; such, for instance, as ninety parts sugar to ten parts water. This concentrated syrup contains, when cold, seventy parts of crystallized sugar, and twenty parts sugar held in solution by the ten parts water; forming, therefore, thirty parts of syrup; which drains off as molasses, and can be reconcentrated in a succeeding operation.

But the concentration of syrup carried so far is detrimental to the formation of a large and well-developed grain, and very much obstructs the drainage of the mass. This fact was so clearly discovered by Dutrone in the course of his experiments, that he laid it down as an established principle, *that sugar should be allowed to crystallize in a large quantity of water;* and that he is perfectly correct is beyond all doubt. Planters have, I know, very erroneous ideas of the operation of Dutrone's principles, and from such misapprehension, formed without due consideration, they become so prejudiced that they will not listen with any degree of patience to arguments in favour of his views; however sound, or convincing, those arguments may be.

I conceive it to be so important to the interests of the planting community that it should be well informed as to the direct tendency of Dutrone's principles, that I must endeavour to point out, in a few words, how their application affects those interests; and I would solicit a careful attention.

When a field of sugar-canes is fully matured, the planter's interest would lead him to wish to convert those canes into sugar of as good a quality, in as great a quantity, and in as short a time as possible: not merely raw sugar, to lie in the curing-house for one or two months, but sugar that can be in the market in England (say from the West Indies) before ordinary Muscovado sugar generally leaves the curing-house of the estate.

To accomplish this is quite within the planter's power, even without entailing on him any outlay for expensive machinery; as open evaporators hung over a naked fire, and a curing-house of one-half the usual dimensions, will answer all purposes. The very simple means of defecation already explained having been resorted to, and the syrup evaporated to 27° density, then decolorized by being passed through animal charcoal filters; the evaporation in the same open pans is resumed and continued, until the thermometer rises to 230° Fahr. or 88° Reaumur, when the skip is struck, without having incurred the smallest risk from burning or increased colour. This syrup then contains, according to Dutrone's table, 52 lbs. of sugar which will crystallize on cooling, and 48 lbs. of sugar held in solution by 28¾ lbs. of water.

Such syrup, placed in curing-cases and properly treated, will yield in eight days, 520 lbs. of well-drained sugar, to 767½ lbs. of syrup drainings: the former being very large, strong-grained sugar, fit for market after an hour's exposure to the sun; and the latter being returned immediately to the evaporating pan, to be once more brought to the density indicated by a temperature of 230 Fahr. Now, in pursuing such a system as this, the planter would insure, if not the whole, at least 90 per cent. of the sugar contained in the clarified liquor when it entered the evaporating range: thus, instead of having from 30 to 50 per cent. of molasses drained from his sugar in the curing-house, together with constant drainage during all the voyage to England, and even afterwards until sold; he would have only 10 per cent. of molasses, all of which would be drained off and delivered, in the curing-house, without the further drainage of one ounce, up to the period of its sale in Europe. Even 10 per cent. is a much larger amount of molasses than need be obtained; in stating that per-centage, therefore, I have taken a wide range. The grand objection to Dutrone's plan has always been the fancied loss of time, labour, and fuel occasioned by the repeated concentrations or reboilings entailed; but practice on an extensive scale has completely confuted this objection, and clearly shown that his system secured a nett profit of full 45 per cent. over that of the old French school, whilst at the same time it was found to occasion a saving in labour of one-eighth.

In Dutrone's day, boiling in vacuo, or by the other low temperature plans, was not known; and consequently he could not enter on methods which that principle has afforded *us* the means of pursuing. In his time, as in ours, a temperature of 230° to 232° Fahr. could not be exceeded without causing a very serious injury to the sugar, and consequent loss; but we can now concentrate our syrups to whatever density we desire, at a temperature so low that no injury can result to the sugar. It therefore behoves the planter to avail himself of the advantages and facilities offered by the low temperature principle; always bearing in mind, however, the valuable truth contained in the maxim enforced by Dutrone, viz., *that sugar should be allowed to crystallize in a large quantity of water.* From a disregard of this excellent rule, great loss of produce, time, and labour occurs; as will be evident from the following explanation:—When the crystals of sugar form in a large quantity of water, the general motion (influenced by attraction) which conduces to that action is free and unimpeded; which results in the development of large-sized and regularly-proportioned crystals, that are known under the name of sugar candy. Now, under such circumstances, the sugar combines with water (chemically) in far greater proportion than when crystallization takes place in a limited quantity of water; hence this sugar is not so sweet as common sugar. But no part of the water, with which the sugar has united itself in the formation of a large and bold crystal, is separable by drying, washing with alcohol, or other methods, save by the decomposition of the sugar itself; thus these crystals may be dried by the heat of the sun, or in a stove, without losing one iota of the water that is chemically combined with the sugar. Next, when such large and perfect crystals are formed, the drainage of the syrup (that is uncrystallized) is immediate and complete; not occupying one-tenth of the time necessary under the usual practice. And lastly, if it be thought advisable to cleanse the crystals by *liquoring*,* one application of the solution of pure white sugar is alone necessary to whiten them perfectly: but it is not likely that such liquoring can be requisite; only inasmuch as it adds to the appearance and value of the beautifully crystallized mass. But with ordinary sugar, not only is the time occupied in drainage excessive, but the purification and whitening of the crystals cannot be effected under less than four applications of syrup or liquor.

The planter, then, may concentrate his syrup in open pans until it is comprised of three parts sugar and one part water; and afterwards transfer it to the vacuum-pan, either Wetzal's or Kneller's, in one of which it undergoes a further evaporation at a temperature of from 160° to 180° Fahr. I have already said that some sugar-boilers concentrate their syrups until they contain ninety parts sugar to ten parts of water: but from what I have just observed, it is obvious that such a practice is entirely wrong; and I offer a recommendation of no common importance, when I advise a practical recognition of Dutrone's maxim to boil low: to keep at least to between 15 and 20 per cent. of water.

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* *Liquoring* is the application of a thick solution of pure sugar to cleanse the crystals. I believe the French term such solution *claircè*.

I believe I have now gone over the whole course which may be advantageously pursued by the planter in the boiling-house, from the defecation of the juice to the concentration of the syrup. It is, however, necessary to touch slightly on the system commonly pursued at present in our colonies, in regard to the three processes belonging to the boiling-house department.

The defecation of the juice and cane-liquor appears to be treated by our planters as a matter of very slight importance; whereas, in reality, it is an operation on the successful performance of which, the fate of the crop, as regards its quality and quantity, very materially depends. The evaporation of the watery parts contained in the liquor, is a simple and unimportant process compared with that of defecation. To clarify, to defecate the juice thoroughly or not, is merely a plain question, which may be put in other words: viz., does the planter, after the expense, labour, and anxiety he has bestowed on the cultivation of his canes, desire that one-third or one-half of the sugar contained in them should be deliberately sacrificed or not? If he does not wish such a ruinous waste of property, then let him attend to the defecation of his juice: the succeeding operations of evaporation, concentration, and curing are then made easy, and in a very eminent degree insured.

It never must be lost sight of, however, that the condition of the juice should be cared for, and rendered in a manner certain, by a rational and judicious course of cultivation; by means of which the juice comes as pure as possible into the boiling-house. This we may denominate "making sugar in the field," and it will lighten much the labours and anxieties in the boiling-house.

Next to the defecation, follows the evaporation of the cane-liquor,—a process of the most simple and straightforward character; attendant on which there is no risk, provided the pans be kept properly filled, and a good brisk fire be urged. The more complete the defecation, the more simple and safe is the evaporation: cane-liquor, brought by the separation of its impurities to a state of sugar and water, cannot present any difficulties in evaporating the excess of water; but the case is widely different when the liquor only partially clarified, enters the evaporating ranges.

The form of evaporators I have been careful to illustrate and explain; and if there be planters who still use the old-fashioned boilers, let me again urge on them the necessity of changing them for those of an improved form. The old elliptical copper boilers, if broken up and sold as old copper, would fully pay for the purchase of a very desirable range of iron evaporators.

The question of improvement by means of animal charcoal, I have endeavoured to simplify; and its adoption need not in any way disarrange the present routine of the boiling-houses.

In their present condition, this and other simple yet highly important improvements may be carried out, without entailing the necessity of making other than the most petty alterations.

Concentration, as at present practised on sugar estates, unprovided with a separate apparatus, is faulty in the extreme. Even the late Mr. Whitehouse, of St. Mary's, Jamaica, a most intelligent planter and clever writer, committed the great mistake of questioning the advantage of the vacuum-pan on sugar estates. This he did because he had seen sugar made in open pans fairer in colour than, and of as good a grain as, that made in the vacuum-pan, at some 80° lower temperature. But he did not take into consideration the following important points:—First, that in all probability the juice in the open pans was rich and highly elaborated, whilst that in the vacuum-pan was very likely the juice of young plant canes, grown on some highly manured land, and consequently abounding in impurities; secondly, that from not understanding thoroughly the exact effects produced by boiling on the low principle, the boiler-men might have considered it unnecessary to pay the same attention to the clarification of the juice, as they would in concentrating in open pans: perhaps attributing to the vacuum-pan some wonderful properties which it does not possess; for instance, the vacuum-pan can no more convert albuminous matter and other impurities, or uncrystallizable syrup, into sugar, than the open tache can; thirdly, that although the sugar made in the open pan was superior in quality, yet that the molasses or uncrystallizable syrup resulting from that sugar so boiled, may have been twice or even thrice as much as that made in the vacuum-pan; and lastly, that (under the circumstances of the case) the vacuum-pan, having no one to conduct its operations who thoroughly understood its management, very probably was mismanaged, and consequently did not exhibit its full value as a concentrator.

The temperature at which syrup is usually discharged from the tache (or what is termed "skipped"), is about 240° to 250° Fahr.; or no less than from 10° to 18° Fahr. beyond the point to which evaporation can be carried without injury from burning: or, rather, of decomposition from the effects of over-heating.

Then, during the time taken in ladling out the skip, so much more is injury accruing; which certainly is more limited where a large discharge valve allows of the contents of the tache being drawn off quickly. If any planters are determined to continue the concentration of their syrup in open pans over a naked fire, let them at least have the concentrating tache separate from the evaporating range, and hung over a furnace of its own; that the temperature may be modified, or increased, without affecting the operations in the other pans.

When syrup is being evaporated, or concentrated, in open pans, the thermometer will show, in a moment, the density to which it has arrived at any period of the operation: thus, when the syrup is fifty parts sugar and fifty parts water, its boiling point will be about 219° or 220° Fahr.; when sixty of sugar and forty of water, it will be

224° ; when three parts sugar and one part water, it will be about 229° ; when five parts sugar and one of water, it will be about 238° or 239° ; and so on. By this it will be seen that the thermometer is an excellent guide in shewing the several points at which the concentration has arrived; and when joined to the practical experience of the intelligent boilerman, no mistake whatever need be made, nor any risk of injury be incurred.

When the syrup has been concentrated to the desired point, the next object is to secure the granulation or crystallization of the sugar contained, in as general and perfect a manner as possible, so that the whole of the crystallizable sugar may assume the form of fine, bold crystals; and when that formation is complete, the syrup or mother-water (*id est*, the sugar held in solution by the water which is in excess) may drain off freely and rapidly, leaving the sugar devoid of that clammy stickiness so observable in sugar that is high boiled and imperfectly drained. To attain this end in as perfect a manner as is desirable in practice, the planter must make up his mind to two things: viz., to discard the old fashioned and highly objectionable coolers now commonly used, and entirely to abolish the use of hogsheads, tierces, and barrels, as curing vessels.

The coolers in their present form are peculiarly well adapted to counteract the objects the planter has in view; and the casks are altogether so barbarous, that it is wonderful any set of intelligent men can persist in their use.

Instead of these, there should be one cooler, or rather receiving vessel, to receive the concentrated syrup from the tache or the low temperature apparatuses (described as Wetzal's and Kneller's); and from this receiver the syrup should be immediately carried into the curing-house, and deposited in the curing-cases. If the syrup be concentrated in an open tache, I will suppose the skip to be struck when the temperature rises to 230° or 232° Fahr. (low boiling); and the curing cases require then to be of the form recommended by Dutrone: viz., 5 ft. long and 3 ft. wide, with sides 9 inches deep, increasing to 15 inches in the centre, by means of two planes forming the bottom, inclining 6 inches. Across the middle of the bottom, where the two inclined planes are joined, a channel is formed, along which twelve or fifteen holes (of an inch in diameter) are made, for the syrup to drain through when the crystallization is complete. These cases are lined with very thin sheet-lead, and the holes may have small tubes of 1½ or 2 inches long, neatly soldered on to the lead lining. The particular size and form of these cases were very correctly ascertained by Dutrone, from numerous careful experiments, to be the very best for the purpose required; and if made and lined as above described, they offer every possible advantage for crystallizing and draining.

I have had from five hundred to six hundred of these cases made, for myself and friends in the East Indies; and from a long experience, I can answer for their very satisfactory accomplishment of the objects stated by Dutrone.

In working with these cases, it is advisable to lay a piece of coarse matting, or wire-gauze, of about six inches wide, supported by small cross pieces of wood, along the whole length of the case, and immediately above the draining holes. When the skip is struck, it runs into the cooler or receiver, from which it is immediately removed and placed in the curing cases; taking care to half fill only each case, in order that the other half may be filled up from the succeeding skip. When the second half is added, the whole must be well stirred up, so as to amalgamate the two portions thoroughly, and secure an equal temperature throughout the mass.

Whilst it is cooling down, no drafts of cold air should be suffered to enter the curing-house; for the process requires to be gradual and unaccelerated. After some hours (varying from twelve to twenty-four), a crystallization will be apparent at the surface, sides, and bottom; when it will be necessary to stir up (with a wooden knife) the whole mass; gently and gradually disengaging the crystals at the bottom and sides, and distributing them throughout the body of the liquid.

The effect of this will soon be discernible in the accelerated crystallization which thereon ensues; but, if circumstances seem to render it advisable, a second very gentle movement may be given to the mass, two hours after the first. It must then be left perfectly uninterrupted for three, or perhaps four days; when the whole will have become quite cold, and crystallization taken place throughout. The plugs, which stop up the holes for drainage, are then withdrawn, and in the course of three or four days the drainage will be complete. If the whole process has been carefully attended to, the space of four days is very rarely exceeded, as the syrup drains off very rapidly.

Arrived at this stage, the sugar contained in the case is ready for liquoring; and, should the planter decide on this simple means of enhancing the value of his produce, a solution of fine white sugar is made, and poured over the surface of the sugar in the case: taking care, first, to scrape the top nicely and evenly. This percolates through the mass, and cleanses the crystals; but, if liquoring is not had recourse to, the sugar, immediately the syrup has drained off, should be taken from the case, dried in the sun, and at once packed for shipment.

When the syrup is concentrated in the Wetzal's or Kneller's pan, it is generally discharged at a temperature not exceeding 160° to 180° Fahr.; consequently the cooling would be too rapid were the syrup to be placed in cases so shallow as those just described: it is, therefore, expedient to have others made more suitable. These may be in every respect similar to Dutrone's; only, that instead of the sides being only 9 inches deep, giving 15 inches in the centre, they may be 15 inches deep, giving 24 inches in the centre; this greatly increases their capacity, and, as a matter of course, so enlarged a mass will take a more considerable time in cooling. In giving these latter dimensions, I have in view the practice so earnestly recommended, of boiling low: notwithstanding that the low temperature principle be taken advantage of.

In no case can crystallization proceed under such favourable circumstances as when the syrup is thin and limpid; so that the crystals, in forming, may have freedom of motion. On the contrary, a thick and tenacious syrup opposes insurmountable obstacles to a perfect crystallization; and consequently the crystals are small, irregular, weak, and clammy; thus being difficult of drainage. Many boilers think, that because they can evaporate almost the whole of the water contained in their syrups by the low temperature principle, without fear of burning, &c., that it is incumbent on them to concentrate very high; seemingly unconscious or unheedful that they are running counter to the first principles of crystallization. I must, therefore, once more repeat, that if the planter wishes to secure a good description of sugar, which will drain readily and thoroughly, he must boil low.

I have said nothing of cones for curing sugar, for this simple reason, that in all the boiling-houses where I have seen them used, I never could discover any benefit that was derived from them; whilst, on the contrary, I know that they entail a great deal of extra labour, and require a very extensive curing-house. I therefore cannot recommend their use to the sugar-planter.

A very simple and efficacious means of hastening the separation of the syrup (or molasses, if it may be so called) from the new sugar, is that afforded by Hague's patent; which consists in forming a vacuum below the curing-vessel, in consequence of which, the air rushes down through the body of the sugar, carrying with it the syrup; thus completely freeing the sugar of its syrup (or molasses) in the course of a few minutes.

A Mr. Cooper has recently patented a pneumatic pan, constructed on the same principle, but which is said to be an improvement on that of Hague's. The apparatus consists of a pan, which is provided with a false bottom made of cane-work; into this the syrup is skipped direct from the concentrating tache, and, after a sufficient time has been allowed for crystallization, a vacuum is formed in the space between the two bottoms, and the syrup is forthwith drawn from the mass, leaving the sugar free and fit for drying.

Where cases such as I have described are used, nothing can be easier than having an air-tight apparatus made, which can be screwed on to the bottoms of the curing cases in rotation, as they are ready; and, by means of an air-pump the syrup or molasses can be drawn off from the sugar; thus rendering the delay of three or four days in drainage unnecessary. In this manner, immediately the crystallization of the sugar is completed, it could be freed from the syrup in a few minutes; by which rapid curing, the dimensions of the curing-house need be only one-third the size it would otherwise require to be. After the sugar is freed from its syrup, it should be exposed in the sun to dry, previous to being packed for shipment.

The heat of a tropical sun soon accomplishes this: the sugar is then put into boxes and well beaten down, which is managed by means of a thick piece of plank that fits nicely into the box. Thus a quantity of sugar is put into the box, the piece of plank is introduced and well beaten down by a heavy piece of wood; then another quantity of sugar is added, and the plank is again introduced and well beaten down; and so on until the box is quite full, when it is headed up and braced strongly. These boxes usually contain from 400 to 500 lbs. or rather more, and accordingly go four or five to the ton as freight.

Sugar sent home from Singapore in such boxes, was always found to weigh heavier on their arrival in England than when they left the estate; and in no case was any loss known to accrue.

Let the West India planter contrast this simple fact with he notorious loss attendant on shipping sugar in hogsheads, tierces, and barrels; and then ask himself, why he should longer submit to such a ruinous waste of property as arises from this most barbarous system. Surely hewill not persist in a wasteful practice which has nothing to sanction it but custom.

In treating, as I have done, of the system of boiling low, I have continually substituted the word syrup for molasses; because, if the system of manufacture be pursued which I have laid down, the syrup will be so pure that it cannot by any means be called molasses. On the contrary, it is merely crystallizable sugar in solution; and the evaporation of the water holding it in solution is alone necessary to admit of the sugar assuming the crystalline form and character.

This concentration may be repeated until the very smallest amount of syrup remains, to be passed to the distilhouse under the name of molasses; and I think I have gone far in stating it so high as 10 per cent. It must also be borne in mind, that if this syrup be boiled on the low temperature principle, or not allowed to exceed 230° or 232 Fahr. in the open tache, it may be repeatedly concentrated, without receiving any injury, or increasing its colour, except in the most trifling degree; which can even be completely remedied by passing it through animal charcoal. Thus, if 10 per cent. of the sugar originally contained in the juice, be ultimately passed into the distilhouse as molasses, it certainly is as much as, or more than, should be; for, in addition to this, I have calculated that 2 per cent. also finds its way into the distil-house, with the skimmings, &c.

To facilitate the operations in the curing-house, the temperature should be kept as nearly as possibly at 90° Fahr. which in a tropical climate is no difficult matter; especially if the glass windows, which I have already noticed as so indispensable, are provided.

Recapitulation.—I shall attempt but a very brief recapitulation of the foregoing instructions: but, in doing so, I must beg to direct attention back, even to the early chapters on the cultivation of the cane-plant. It will be remarked that I have, throughout, been at pains to show that it rests with the planter himself, to choose a good description of cane, a congenial climate, and suitable soil; to render the seasons subservient to his objects; to correct a bad and enrich a poor soil; to keep up a constant and unimpaired fertility; to apply those substances alone, as manure, which tend to render the juice of the cane rich in sugar.

That it rests with himself whether he will have good cane-juice instead of bad; whether that juice shall be obtained in a large or small quantity; whether the complete defecation of that juice shall be effected or not; and whether its concentration, and the subsequent crystallization and drainage of the concentrated syrup, shall be conducted on those principles which science and experience teach us are right; or whether they are to be violated in every particular. All these points, and many more, rest entirely with the planter himself. I can but direct his attention to those facts which my own experience and that of others have demonstrated; I can but point out to him what is right and what is wrong, and counsel him as to the course he should pursue: but it is for him to decide whether he will avail himself of that information, and be guided by that counsel.

Before going over the more important objects which have been so fully stated, it is necessary to show what, in reality, can be obtained from one acre of land, in the shape of canes, cane-juice, sugar, and molasses. Amongst planters, it is pretty generally known that an acre of canes will yield a certain number of cart-loads of canes, which will produce an amount of sugar dependent on its peculiar richness, and a quantity of rum proportionate to the sugar potted; but beyond this unsatisfactory information extremely little is known or cared about. Not one managing planter in five hundred can tell how many tons of canes any given field has yielded; what loss has been sustained from those canes being inefficiently expressed; of what density the juice was; what amount of pure sugar that juice should in reality have produced; what loss has really been sustained by unskilful and negligent manufacture; or what saving can really and practically be effected by a rational course of cultivation and manufacture. These are matters uncalculated and unheeded, to a degree perfectly surprising.

In the former part of this work, I endeavoured to show that, by a simple system of cultivation, the cane-plant can be made to yield a maximum amount of pure sugar accompanied by the least possible quantity of nitrogenised matter; a strict attention to which, will not only insure a large proportion of good sugar, but will be effecting that object so much talked of by planters, but so little understood, viz., *making sugar in the field.* It must be especially borne in mind that, to produce sugar, very large canes are not required: are not desirable; but that moderate-sized and very sweet canes constitute the *ne plus ultra* of the cultivator's desires. Large quantities of woody fibre and water, are not desirable in the cane; but sugar, in abundance, and as pure as can be induced.

An acre of plant-cane, generally ranges from thirty to thirty-five tons of canes, ready dressed for the mill; and, if the superior description of mill be used, and the saturation of the partially expressed stalks, such as already described, be followed, I have no doubt whatever but that full 80 per cent. of the juice may be obtained; and that such juice will declare a higher density than in any other case, by reason of the whole crystalline deposit in the cells being obtained by that peculiar method. In the following calculations, however, the range is taken of from twenty-five to thirty tons; and a careful examination of the products will make apparent the enormous loss sustained by the planting interest, from the present very negligent and wasteful modes of cultivation and manufacture: especially the latter.

PRODUCE OF ONE ACRE, IN JUICE AND SUGAR, WHEN IT YIELDS TWENTY-FIVE TONS OF CANES.

Juice obtained.	Amount of juice.	LBS. OF SUGAR CONTAINED.			LESS IN MOLASSES, AND SKIMMINGS, AT 12 PER CENT.			AMOUNT OF DRY SUGAR YIELDED BY ONE ACRE, LBS.		
Per cent.	lbs.	At 18 per cent.	At 20 per cent.	At 22 per cent.	At 18 per cent.	At 20 per cent	At 22 per cent.	At 18 per cent.	At 20 per cent.	At 22 per cent.
					lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
70	39,200	7056	7840	8624	588	653	718	6468	7187	7906
75	42,000	7560	8400	9240	630	700	770	6930	7700	8470
80	44,800	8064	8960	9856	672	746	821	7392	8214	9035

PRODUCE OF ONE ACRE, IN JUICE AND SUGAR, WHEN IT YIELDS THIRTY TONS OF CANES.

Juice obtained.	Amount of juice.	LBS. OF SUGAR CONTAINED.			LESS IN MOLASSES AND SKIMMINGS, AT 12 PER CENT.			AMOUNT OF DRY SUGAR YIELDED BY ONE ACRE, LBS.		
Per cent.	lbs.	At 18 per cent.	At 20 per cent.	At 22 per cent.	At 18 per cent.	At 20 per cent.	At 22 per cent.	At 18 per cent.	At 20 per cent.	At 22 per cent.
					lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
70	47,040	8,468	9,408	10,348	705	792	862	7,763	8,616	9,486
75	50,400	9,092	10,080	11,088	757	840	924	8,335	9,240	10,164
80	53,760	9,677	10,752	11,827	806	896	994	8,871	9,856	11,173

From these statements, it appears that if we obtain from our canes 70 per cent. only, of their weight in juice, and if that juice is only of a density of 10° by Baume's saccharometer (about 18 per cent.), we may secure from them, in the former case (25 tons of canes per acre), 6,468 lbs. (about $2\frac{8}{9}$ tons) of dry sugar, and 588 lbs of molasses; in the latter case (30 tons per acre) we may obtain 7,763 lbs.

(nearly 3½ tons) of dry sugar, and 705 lbs. of molasses from one acre of land.

But if the density of the syrup should be 12° Baume, or 22 per cent., at 25 tons of canes per acre, we might obtain 7,906 lbs. (more than 3½ tons) of dry sugar, and 718 lbs. of molasses, from one acre; or if at 30 tons of canes per acre, then 9,486 lbs. (nearly 4¼ tons) of dry sugar, and 862 lbs. of molasses, from one acre of land.

If we go up the scale to 80 per cent. of juice, from 30 tons of canes, at 12° Baume, we arrive at the startling amount of 11,173 lbs. (or very nearly 5 tons) of dry sugar, and 994 lbs. of molasses, from one single acre of land. This is certainly double the quantity of sugar usually potted from an acre of good plant-canes. I say potted, because a ton hogshead seldom weighs more than 1,700 to 1,800 lbs. when it reaches Europe; but, in addition to the sugar actually potted, we must allow for about 60 to 80 gallons of molasses per ton: say, from 2½ tons, about 175 gallons of molasses, or 175 gallons of rum.

This would bring the yield in the latter case to 2½ hogsheads, weighing in England 1,750 each = 4,375 lbs. of sugar, and 175 gallons of rum, 20 per cent. over proof; to compare with which we may take the former case of 11,000 lbs. of sugar, weighing the same in England, and 83 gallons of rum, 15 per cent. over proof.

In comparing these two statements, let the planter inquire minutely as to the number of managers who do actually and truly send to England 4,375 lbs. of sugar, and 175 gallons of rum, as the produce of one acre of land. Not merely send it from the estate, for that is not the question, but land in England that quantity. After satisfying himself on this point, let him look calmly, and without bias, into the calculation I have made; and, if his mind be divested of prejudice, there can be no doubt whatever but he will acknowledge, that 30 tons of canes is no unusual quantity from one acre; that 80 per cent. of juice *may* be obtained from such canes, and that a density of 12° Baume's saccharometer, or 22 per cent., is neither impossible nor improbable, as 24 and 25 per cent. are sometimes obtained. Having clearly acknowledged these primary positions, there cannot remain the shadow of a (reasonable) doubt as to the perfect practicability of securing the results I have stated. But, as a ready reference, I give the following brief summary of those points which should chiefly engage the planter's attention :—

1. The selection of two good descriptions of cane for cultivation on every estate.

2. The selection of a good, strong, workable soil; such as brick-mould, &c.

3. The cultivation of the land by means of the plough and other agricultural implements, instead of by manual labour. The constant ploughing and pulverization of the soil. The careful planting, moulding, cleaning, banking, and trashing of the cane: being very particular to have no green leaf taken from the growing plant.

4. The strict application of the principles so fully explained, viz., to manure the cane with its own trash, ploughing it in whilst green; to use as manure other vegetable substances, in order to form humus in the soil; and very especially to eschew all manures supplying ammonia to plants: such as guano, cattle-pen manure, &c.; also to be very cautious in applying manure containing large quantities of saline substances: such as salt-water, sea-salt, sea-mud, ashes of plants, &c. &c., as they do great injury when in excess.

5. The careful consideration and determined pursuance of irrigation on a proper and practically useful scale.

6. The selection of really good and honestly made implements.

7. The judicious construction and arrangement of the manufactory, and the extreme importance of possessing machinery of the most improved character, and the best workmanship.

8. The enormous loss that is sustained by estates, from

the inefficient action of most of the mills now in use; the utter neglect of the all-important subject of defecation; the unsuitable character of many of the evaporating pans now in use; the ruinous method of concentration so commonly practised; and the improper courses adopted in the mismanaged processes of crystallization and subsequent drainage.

All this may be remedied in an extremely simple manner. —1st, By the employment of good and efficient mills and machinery. 2ndly, By adopting the means of defecation pointed out; so as to bring the cane liquor, as nearly as possible, to a state of pure sugar and water before it is allowed to enter the evaporating pans. 3dly, When there, by being careful always to keep a sufficient quantity of liquor in the pans, to remove all risk of burning; and to skip the charge when the temperature denotes 230° of Fahrenheit. 4thly, By concentrating on the low principle to the desired proof, if that indicated by 230° or 232° does not please; but paying great attention to the maxim of boiling low, so as to secure a perfect crystallization and a rapid draining, that there may be nothing further to drain off when the sugar quits the curing-house. 5thly and lastly, By drying the sugar before it is packed for exportation.

By paying attention to these points, I am convinced that the planter will find his land yield him twice or thrice what it hitherto has done; and that at a cost very little beyond what he now expends without any profit to himself.

There can be no question, that, from a combination of circumstances, such as inefficient machinery, gross neglect, and general mismanagement, not more than one-half the sugar contained in the cane is obtained by the planter. It is to remedy this that I have laboured in writing this work. I know what a thankless and ungracious office it is to find fault; yet, to overcome the ruinous defects of the present system of cultivation and manufacture, it is imperatively necessary that every fault be exposed, before we can hope for a beneficial change of system. In concluding this important subject, I can only earnestly call on the planting community to arouse their energies, and to keep pace with the vast improvements that are springing up in every department around us, instead of suffering the reproach of being the only profession in which no improvement is manifested.*

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* The recent researches of the eminent French chemist, M. Casaseca, upon cane-juice, at the Havanna in Cuba, have demonstrated clearly the enormous loss which sugar planters suffer by the imperfection of their manufacturing processes. His results confirm those previously made by M. Peligot, in Paris, and show that cane-juice evaporated in vacuo at the atmospheric temperature, yields in 100 parts,—

Crystalline white sugar	20·94
Water	78·80
Mineral substances	0·14
Organic matter, different from sugar	0·12
	100·00

The cane from which the above juice was drawn is called *canade la tierra*, in Cuba. The juice of the Otaheite cane is identical with the preceding. But the proportions of ligneous fibres in the two canes are very different; that of *la tierra* containing, according to M. Casaseca, 16·4 per cent., while that of Otaheite contains only 10·0. Other canes, however, differ in this respect considerably from these two varieties. The average quantity of grained sugar obtained from cane juice in our Colonial plantations, is probably not more than *one-third* of the quantity of crystalline sugar in the juice which they boil.—(*Ure's Dictionary of Arts and Manufactures. Supplement.*)

CHAPTER IX.

ON THE DISTILLATION OF RUM.

Rum is the spirit which is made on sugar estates from the molasses and skimmings resulting from the manufacture of sugar.

It is never made from sugar itself, but from the molasses that drains from the sugar during the process of curing: although, in Calcutta and many other places, there is a spirit made from treacle, bad sugar, &c. which is sometimes called rum; but it is in no way like the pure spirit manufactured in Jamaica. Being made from molasses and skimmings, it is advisable to notice those two products; and, together with them, the exhausted wash commonly named *dunder*.

Molasses, proceeding from sugar such as that made in our colonies, comprises crystallizable and uncrystallizable sugar, gluten or albumen, and other organic matter which has escaped separation during the process of defecation and evaporation, together with saline matter and water. All these more or less abound; according to the soil whereon the canes are grown, and the degree of attention that has been paid to the manufacture of the juice. Thus, in rich alluvial soils, the quantity of saline matters is very great in the cane-juice, and, as a natural consequence, in the molasses. Avequin gives the following analysis of molasses, resulting from canes grown in the rich alluvial soil of Louisiana, as comprised in 20 lbs.: good crystallizable sugar, 15 lbs.; salts and organic matter, 1 lb.; and water, 4 lbs. He states the salts to be acetate of potash, chloride of potassium, sulphate of potash, biphosphate of lime, silica, and acetate of lime. The organic matter he states to be gum, or a substance much resembling it, constituting about one-ninth of the foreign matters contained in the whole.

According to this analysis, he makes out the good crystallizable sugar to be 75 per cent.; the saline matter to be 4·35 per cent., and the organic matter only ·65 per cent. of the whole. It appears to me that this analysis must be incorrect, to a degree quite absurd; for he gives us all the sugar contained, as "good crystallizable sugar:" he can discover no *un*crystallizable sugar, whilst he declares the presence of 4·35 per cent. of saline matter. It is difficult for us to reconcile this with what we know commonly happens: first, we must convince ourselves that the manufacture of the sugar had been perfected under the most favourable conditions, in order to prevent the formation of glucose or uncrystallizable sugar, by burning or concentration at a high temperature. Secondly, that so large a proportion of saline matter could exist in contact with sugar, without rendering a portion of it uncrystallizable. Thirdly, that 4 lbs. of cold water is capable of holding in solution 15 lbs. of sugar!! When we can credit all this, we may then place some faith in such an analysis; but until we can reconcile these improbabilities, we cannot but consider it as being an unaccountable error.

The generality of molasses produced in our colonies, has much more organic and far less saline matter, whilst water is more abundant; and the crystallizable and uncrystallizable sugar exist, in greater or less relative proportions, according to the circumstances attendant on the manufacture of the sugar from which the molasses has drained. These circumstances chiefly relate to the action of alkalis, acids, and heat, together with that of the azotised substances, such as gluten or vegetable albumen, on the crystallizable sugar; which is thereby changed into uncrystallizable sugar. Thus, an excess of lime used in clarification, the excess of an acid, whether used as a reagent, or produced by the action of heat (see page 347), or an excess of heat during concentration, or its effects during evaporation when the vessels are not properly filled, convert crystallizable into uncrystallizable sugar: and to these we may add the action of the azotised as well as the saline substances contained in the cane-liquor. It will be seen, therefore, that the quality of molasses depends, not only on the quality of the cane-juice, but also on the degree of skill and attention bestowed on its manufacture. According to the plans laid down in the preceding chapters, an extremely small quantity of molasses should result in the manufacture of sugar; and such molasses ought to be comprised of uncrystallizable and (very little) crystallizable sugar and water alone: except in cases where saline substances abound in the juice and cannot be got rid of; then, of course, these would be added to the sugar and water comprising the molasses.

Molasses, which contains an azotised substance, such as glutinous or albuminous matter, possesses in itself elements necessary to fermentation: *id est*, it contains sugar, water, and gluten; which latter, acting as a ferment, speedily disposes the whole mass to fermentation: thus we very frequently see molasses fermenting in the receiver in the curing-house, before it can be used in setting up wash. This tendency to fermentation is greatly increased by the addition of water, which reduces its density; hence we find, in curing-houses where clay, pond weed (seèwah), or wetted gunnie bags are placed on the sugar to whiten it, that the water in these, mixing with the molasses, causes fermentation very quickly.

Skimmings comprise the matters separated from the cane-juice during the processes of defecation and evaporation: thus we have the thick crust of scum thrown up in the clarifiers, the scum of the precipitators and evaporators, and the precipitates in both clarifiers and precipitators; together with these, there is a proportion of cane-liquor mixed with the various scum and precipitates, and a large quantity of water which has been used in washing down and cleansing the various vessels and gutters ; and further, every time the liquor is " boiled off" in the evaporators (which occurs, perhaps, every Saturday night), there is a quantity of what is termed "sweet liquor," which results from the washing the boiling pans, &c. receive. All these, running together into the distil-house, become mixed in the skimmings receiver, and are denominated feculencies ; the liquor of which, when clarified, is drawn down, as will be explained, under the name of Skimmings.

It therefore is evident, that these feculencies are comprised of the foreign matters existing in cane-juice: such as woody fibre, gluten, green fecula, wax, gum, and earthy matters, together with more or less cane-liquor, water, and the substances used in defecation. The scum and precipitates, deprived of their accompanying liquor, are pronounced by Avequin to be composed of waxy matter, green matter, albumen, woody fibre, biphosphate of lime, silica, and water.

Skimmings then, contains, in itself, the elements essential to fermentation; and, accordingly, we find that it very rapidly passes into fermentation when left to itself: but, in consequence of the glutinous matter being in excess of the sugar, this latter is speedily decomposed, and the second or acetous fermentation commences very frequently before the first is far advanced.

When the feculencies arrive in the distil house, they are not considered fit for use, until a separation has taken place between the liquid and the solid parts; when the clear liquid is drawn off as skimmings, to be employed in setting up wash.

Dunder or (*redundàr*) is the fermented wash after it has undergone distillation, by which it has been deprived of the alcohol it contained. It is quite amusing to hear the different opinions as to the nature of dunder, and its use in distillation. First we had Bryan Edwards, then Porter, then Ure, then Dubrunfaut, and a host of others, all attributing to dunder qualities that do not belong to it; and all seemingly quite unacquainted with its true properties. It is not more than a few days ago, that I was asked by a person why yeast was not used by our sugar planters as a *ferment*, instead of dunder; intimating in very significant terms, that he considered all the West India distillers a very choice pack of fools. Now, this person says that he has been for a long while manager of one of the largest distilleries in the world. He has written a pamphlet on distillation, with a view to enlighten the minds of all distillers, and no doubt fancies himself possessed of all possible knowledge of the subject. And yet this person, who is a clever man, and no doubt very competent to instruct English distillers, does not know what dunder is, or what is its use in the fermentation of wash.*

Mr. Whitehouse (of Jamaica, now deceased) is the only person in whose writings a correct explanation is given: at least I have met it in no other. But had that gentleman looked somewhat more closely into 'Liebig's Organic Chemistry,' he would have seen an instance quite analogous, mentioned by that great authority, which would have rendered his (Mr. W.'s) ideas on the subject much more clear. Speaking of the wash from which brandy is obtained, and the wort for making beer, Liebig says, "the principal difference in the preparation of the two liquids is, that in the fermentation of wort, an aromatic substance (hops) is added; and it is certain that its presence modifies the transformations which take place. Now it is known that the volatile oil of mustard, and the empyreumatic oils, arrest completely the action of the yeast; and although the oil of hops does not possess this property, still it diminishes in a great degree the influence of decomposing azotised bodies upon the conversion of alcohol into acetic acid. There is, therefore, reason to believe that some aromatic substances, when added to fermenting mixtures, are capable of producing very various modifications in the nature of the products generated."

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* Such as is peculiar to sugar estate distilleries.

The action of dunder, in wash made of molasses, skimmings and water, has a similar effect to hops or oil of hops in wort. It is the aromatic substance which modifies the changes or transformations taking place during fermentation: it increases the density of the liquor, preventing that violent fermentation during which so much alcohol is lost; and keeps the liquor comparatively cool in temperature, and slow in its motion.

Dunder, to be good, should be light, clear, and slightly bitter; it should be quite free from acidity, and is always best when fresh.*

Many causes affect the quality of dunder; and, very often, many rounds of the house are injured from the distiller using dunder that is acid, or that which is heavy, thick, and viscid. When wash is set up with too large a proportion of sweets, the fermentation lasts until all the gluten or ferment has undergone decomposition and become precipitated; when it ceases for want of more ferment: the sugar which still remains in the wash undecomposed is, therefore, incapable of being resolved into alcohol; but instead, passes into the still with the wash, and is discharged in the dunder, still in the form of sugar. The consequence of which is, that the dunder, on cooling, speedily commences to ferment, and works away again, more like wash than dunder; to the great alarm of many juvenile distillers, who term it "live dunder," and very frequently throw it away, fancying it will injure their wash: whereas such dunder should be immediately used to set up fresh wash, or be at once redistilled; as the fermentation only arises from the undecomposed sugar being acted on by the renewed activity of the ferment.

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* Dunder, as it is discharged from the still, runs into *dunder receivers* (placed on a lower level than the still), from which it is pumped up, when cool, into the upper *receivers*, where it clarifies, and is then drawn down into the fermenting cisterns, as required. Well clarified dunder will keep for six months without any injury.

Good dunder (which does not contain sugar undecomposed, as in the above case) may be considered to be wash, deprived by distillation of its alcohol, and much concentrated by the boiling it has been subject to; whereby the substances it contains, as gluten, gum, oils, &c. have become, from repeated boilings, so concentrated, as to render the liquid mass a highly aromatic compound. In this state it contains at least *two* of the elements necessary to fermentation; so that on the addition of a third, viz. sugar, that process speedily commences.

From these observations it is seen that molasses and skimmings each contain sugar, gluten, and water; so that fermentation will occur spontaneously in them without the intervention of any foreign substance, such as yeast; and that dunder contains gluten, and water, as well as an aromatic bitter principle.

With this view of their character and action, we will next proceed to the working detail, and the considerations connected therewith. As the feculencies flow into the distil-house, they are collected in what are termed skimmings-receivers, each of which generally hold about 300 or 400 gallons. They are always lined with sheet-lead, or very thin copper, and are provided with a cock to draw off the contents. A receiver being full, it is allowed time to clarify; after which, the clear liquor, now termed skimmings, is drawn down into the mixing cistern,* if there be one, or otherwise into the fermenting cistern direct: all the scum and impurities remaining in the receiver should be run off into the receiver which is immediately beneath it, and there mixed with 100 or 200 gallons of water, (hot, if it be at hand) and well stirred up for some considerable time, in order to separate entirely all the sugar that may remain entangled in the interstices of the gummy and glutinous textures. This stirring being continued until all the sugar is washed out, the mass is allowed to rest for some time that, it may clarify again; but, if grounds exist for apprehending fermentation or acidity, a little sulphurous acid (from burning one or two sulphur matches) in the one case, and lime in the latter, may be added. When the liquid has clarified, the clear liquor may be drawn off into the fermenting cisterns to aid in setting up the wash. I am aware that this washing of the feculent mass is seldom practised; but it most certainly ought to be, for otherwise the sweets contained will be thrown away, and consequently much loss will accrue.

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* I am quite convinced that there is no necessity for a *mixing cistern;* it only entails additional labour without any accompanying benefit. I would never think of using it.

It must be borne in mind that alcohol, or the spirit which we call rum, is obtainable from sugar alone; the ferment being only necessary to assist the decomposition of the sugar. "The analysis of cane-sugar proves that it contains the elements of carbonic acid and alcohol, minus 1 atom of water. In the transformation of sugar, which is called fermentation, its elements are divided into two portions: the one carbonic acid, which contains $\frac{2}{3}$ of the oxygen of sugar; and the other alcohol, which contains all its hydrogen. Thènard obtained from 100 grammes of cane-sugar, 0·5262 of absolute alcohol (and 0·5127 of carbonic acid); 100 parts of sugar from the cane, yield, therefore, 103·89 parts of carbonic acid and alcohol. The entire carbon in these products is equal to 42 parts; which is exactly the quantity originally contained in the sugar. The alcohol and carbonic acid produced by the fermentation of a certain quantity of sugar, contain together one equivalent of oxygen, and one equivalent of hydrogen; the elements, therefore, of one equivalent of water, more than the sugar contained. The excess of weight in the products is thus explained most satisfactorily: it is owing, namely, to the elements of water having taken part in the metamorphosis of the sugar. The carbon of sugar does not exist in it, as carbonic acid; neither does its hydrogen exist as alcohol: sugar contains, therefore, neither alcohol nor carbonic acid; so that these bodies must be produced by a different arrangement of its atoms, and by their union with the elements of water. In this metamorphosis of the sugar, the elements of the yeast (ferment or glutinous matter), by contact with which its fermentation was effected, take no appreciable part in the transposition of the elements of the sugar; for in the products resulting from the action, we find no component part of this substance."[*]

From this we perceive that the ferment (which in cane-wash is the gluten or albumen) produces by contact the fermentation of the sugar; but that the alcohol is formed from the elements of the sugar itself, minus 1 atom of water, which it derives from the surrounding body of water.

On the quantity of sugar contained in a wash, therefore, is the quantity of alcohol dependent; the ferment being merely the motive power, if I may so term it. The planter, having acquainted himself with these facts, must next endeavour to ascertain the conditions under which fermentation will proceed most advantageously, and the wash yield its maximum amount of spirit. I say spirit, because the sugar planter wants to make rum, not alcohol; if, therefore, the chemist can obtain from 100 lbs. of sugar, 50 lbs. of absolute alcohol, (of 791 specific gravity, at 68° Fahr.) the question is, how much rum of 30 per cent. over proof,[†] should the same quantity of sugar yield in the colonial distil-house? The planter always reckons one gallon of proof rum for every gallon of molasses that he uses. Now if we take common average molasses as containing 65 parts sugar, 32 parts water, and 3 parts organic matter and salts; and suppose that by careful fermentation and distillation, 33 parts (out of 65) of absolute alcohol be obtained, we may then reckon 33 lbs. of spirit, or about 4 gallons; which is a return of about $5\frac{2}{3}$ gallons of rum, 30 per cent. over proof, from 100 lbs. of such molasses.[‡] This agrees well with the planter's calculation.

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[*] Liebig, p. 249.

[†] That is, we will say, 130 gallons of spirit, or 30 over 100, taking 100 as the standard proof; then 30 over proof would be 130. Its specific gravity, with the temperature at 60° Fahr. is 8797.

[‡] 33 lbs. of absolute alcohol (specific gravity 794, at 60° Fahr.) will require

Molasses, however, varies very much in quality, and at the best can only be calculated for according to the amount of sugar it contains. Moreover, that sugar having in part suffered change, cannot be so capable of affording alcohol as pure sugar. The quantity of sugar contained in the skimmings is also reckoned in the per centage of sweets allowed to each cistern of wash: but nothing can be more loose and unsatisfactory than the mode of calculating the saccharine value of skimmings on sugar estates; some planters reckoning it at six gallons to one gallon of molasses, whilst others range from six to ten gallons. It is very evident that the quality of the skimmings must be dependent on the quantity and quality of the cane-juice mixed with it, and the relative proportion of water used in cleansing the various vessels and gutters. I think, on the whole, that it may be taken at from eight to ten gallons of skimmings to one gallon of good molasses.

Were proper instruments used, as they ought to be, there could be no uncertainty on this point whatever; whilst the same instruments would enable the planter to ascertain the density and condition of his wash at any moment.

In setting up wash, the planter must first get his house in good working order; then try the different per centages, to find which suits best the nature of the locality: for it is an established fact that some distil-houses will work best and furnish greater returns at a low per centage, whilst others require a higher per centage.

From my own experience, I believe twelve per cent. of sweets to be the best and most economical per centage that can be adopted: that is, ten per cent. of molasses, and two per cent. of skimmings; which (allowing ten gallons of skimmings to be equal in saccharine value to one gallon of molasses) is therefore 100 gallons of molasses, and 200 gallons of skimmings, to a 1,000 gallon cistern. In my own practice I always use a large quantity of dunder; and,

16½ lbs. of water to reduce it to 30 per cent. over proof; specific gravity 8797, at 60° Fahr. = 49½ lbs. weight.

from very unmistakeable evidence, I am thoroughly convinced that it exercises a most beneficial effect on the character of the fermentation.

When I was a planter in the parish of Trelawney, Jamaica, I used as much dunder as any one in the island : if not a great deal more ; yet the rum I made was very great in quantity, and of the *very highest quality.* At that period, and constantly since, when I had good, light, well clarified dunder, I very frequently employed no water whatever, in setting up my cisterns, preferring the use of dunder entirely ; and the excellent returns I have always obtained by that system, fully convince me of the correctness of the practice. The great object that the distiller has in view, in conducting his fermentation, is to obtain the whole, or as large a portion as possible, of the spirit, that the quantity of sugar he employs is capable of producing : to lose none, or as little as possible, of it by evaporation or acetification.

To accomplish this, I hold it as essentially necessary, first, to keep the fermenting department at as low a temperature as is possible in a tropical climate : say about 75° to 80° Fahr. if it can be accomplished; and secondly, to use a large quantity of dunder. For instance, we will take the case of a 1000 gallon cistern, which we will accordingly proceed to set up. First, we draw down (direct), 200 gallons of well clarified skimmings, 50 gallons of molasses, and 100 gallons of clear dunder ; mix them well together, and allow fermentation to commence. This very speedily occurs ; when other 50 gallons of molasses are added, together with 200 gallons of water, and the wash is allowed an hour or two to attain a general fermentation ; on seeing which, the other 400 gallons of dunder is run into the cistern, and the whole mass is thoroughly mixed. As the fermentation goes on, a little dirt and scum will be thrown up, which is immediately skimmed off; and the temperature of the wash will be found to rise gradually, until it attains from 8° to 10° Fahr. above that of the house itself. If the temperature be found to rise too high, the next cistern must be set up with more dunder and less water; but if the temperature keeps very low, and the wash works too sluggishly, *less* may be used next time. The next criterion is, the period it continues working, and the quantity of rum it produces on distillation; the latter being, after all, the great object for which we are striving.

Many young distillers are always in a desperate hurry to see their fermentation cease, and think that their wash cannot ferment fast enough. I am constrained to say, that there are also some *old* distillers who partake of this absurd anxiety; not reflecting on the nature of the transformations which the elements of the sugar are undergoing, and the conditions which are necessary to ensure a successful issue.

There are those who labour very industriously to show that the fermentation of wort and that of wash is identical; and that, consequently, yeast should be made use of in distilleries on sugar estates: altogether overlooking the difference between wort made from malt, and wash made from the saccharine juice of the cane, together with molasses and dunder.

The employment of yeast on estates has formed the groundwork of many a delusive promise, for which our unfortunate Colonists have had to pay. Amongst others, Jamaica planters no doubt entertain a very vivid recollection of the scheming adventurer, who some years ago played such havoc in some 200 or 300 of their distilleries, whilst he dipped so deeply into their purses. It is necessary, then, again to observe, that the fermenting principle (gluten) exists in large quantities in the molasses, skimmings, and dunder; and consequently that no foreign agent—such as yeast—is necessary. Nay, further, that such is extremely undesirable; as it would change altogether the character of the fermentation.

The fermentation of wash on a sugar estate is somewhat allied to that process which occurs in the making of "Bavarian beer;" with this great difference, that by no means can the temperature be kept so low as is the case in the Bavarian brewery. The similitude chiefly consists in the fermenting wash throwing up no frothy scum, but gradually precipitating the ferment as it decays: or, in other words, instead of the gluten reproducing itself (as is the case with yeast in worts), it is destroyed and precipitated.

The fermentation of a cistern of wash, when it has its proper proportion of dunder, and the house is kept cool, is moderately slow, quite uniform, and ultimately very complete: it throws up no froth or scum (other than the mere extraneous dirt), but gradually precipitates the glutinous ferment as it decays. The temperature may be 90° or upwards; but the alcohol is, to a certain degree protected, from acetification by the aromatic principle resident in the dunder; so that, when distilled, the wash is found to yield from ten to twenty per cent. more spirit than if less dunder had been used, and a higher temperature permitted. It has been fully substantiated that beer made according to the Bavarian process, at a temperature not exceeding 50 Fahr. (see Liebig, page 298) contains fully 20 per cent. more alcohol than that made by the common process. Liebig gives two reasons for this: viz. that by the wort being fermented in very wide flat vessels, its gluten is decomposed entirely by the action of the oxygen of the air, instead of abstracting any portion of it from the sugar contained; whilst at same time the temperature is so low, that the oxygen cannot decompose the alcohol which is formed. With such a fact before us, we cannot do wrong to try (if it be only one "wide, flat vessel") what effect such exposure would have on a body of fermenting wash, set up with plenty of dunder, and in a distil-house kept as cool as possible.

In an experiment of this kind, the shallow fermenting vessel should contain a quantity equal to the cisterns; and the trial wash, on each occasion, should be first mixed all together, then divided, half to the former, and half to the latter, so that no difference could exist in the quality of the wash.

Half a dozen trials would entirely decide whether any benefit accrued from the surface of the fermenting wash being so much greater and so much more exposed to the influence of the oxygen of the air.* We could, of course, never hope to keep the temperature nearly so low as that mentioned by Liebig; but, as I have found in my practice that perfectly open cisterns succeed quite as well as, if not much better than, covered ones, I am led to believe that a much more extended surface would be far from producing unpleasing results. I much regret not having tried this hitherto; but I take the opportunity of suggesting the experiment.

Eight days is considered a very desirable time for a cistern to work off, and mine very frequently took ten or even fourteen days: but I never grew impatient with them; as I always found my account in the excellent return they gave me.

On one occasion, when I was a bookkeeper on an estate in Jamaica, a 2,000 gallon cistern, which I set up at the same proportion as the others, took three weeks and three days in fermenting; so that I thought it never would "die." Every day, for full fifteen days, I expected to see it had subsided; until at length, being in want of the cistern to set up fresh wash in, I distilled it before it had quite done fermenting.

I fully expected to get but a very poor return from it, as it had been fermenting so long; when, to my surprise, I obtained 320 gallons of rum 30 per cent. over proof: which was something like 80 to 100 gallons more than I had ever obtained from such cisterns before. I naturally conceived that the men had made a mistake in setting up the cistern, by putting much more molasses than I had directed; but whether it was so or not, they strenuously denied that such was the case: however, I distinctly recollect that I did not use any water, but altogether dunder, in setting up the wash.

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* The water of rivers and streamlets, as containing oxygen in solution, must be better for setting up wash than that of wells, tanks, or ponds; as, no doubt, the major portion of the oxygen employed, is abstracted from the water.

In fermenting wash, it often happens that the fermentation in a few days will subside entirely, although a considerable quantity of sugar will remain in it undecomposed.

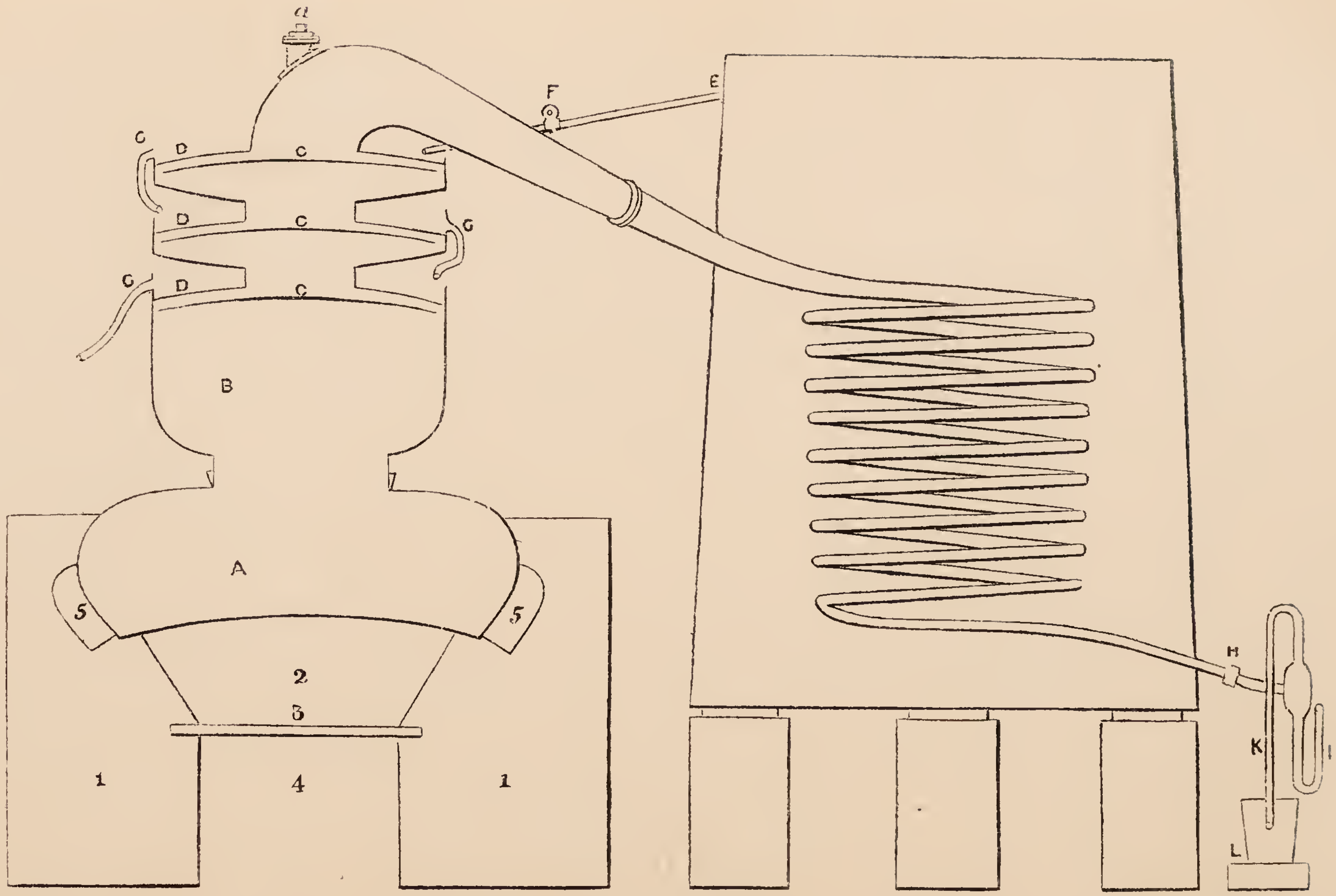
This will arise from two causes: first, from the fermenting agent, gluten, not being in sufficient proportion to the sugar; whereby only a portion, equal to its power of stimulating decomposition, is decomposed, whilst the sugar in excess remains unchanged: secondly, from the action of the alcohol; which is sometimes formed so rapidly and in such quantities, that it precipitates the gluten before it can effect its transformation, and keeps it inert for some length of time, thereby arresting the fermentation for a period.

I believe that in sugar estate distilleries, in nineteen cases out of twenty, where sugar remains in the wash undecomposed, it arises not from the want of ferment, but from its being thus precipitated by the alcohol: hence, when distillation has removed this spirit, the dunder commences to ferment by the renewed action of the gluten.

I have very seldom had this (what is termed) live dunder; from always making my distillermen stir up the cisterns of wash every day, by which means the precipitated gluten was brought into renewed action daily.

In the foregoing, will be found everything that is necessary to the working of the fermenting house. Whilst I would wish to direct particular attention to the facts detailed, I would also wish to warn planters against listening to the designing tales of unprincipled adventurers; who, to fill their pockets, will promise to double the rum crops of an estate, with the same quantity of molasses and skimmings as the planter at present uses. *It must not be forgotten that, by the most scientific methods possible, wash can only yield an amount of alcohol equal to half the weight of the sugar contained in the molasses and skimmings employed: the planter's care being, by a judicious admixture of the materials; by keeping the fermenting house as cool as possible; and by a thorough distillation, to secure the whole, or as much as he can, of this amount of spirit: more he cannot by any possibility obtain.*

PLATE XVIII.



SHEARS'S PATENT SIMPLIFIED DISTILLING APPARATUS

I have already said, that, by pursuing the mode of manufacture (of sugar) which I have recommended, extremely little molasses will accrue; and the same also applies in regard to the skimmings; consequently there will be no more of the latter, than will suffice to give a desirable tone to the former: hence it is evident that the operations in the distil-house will be reduced to a very small scale.

This, indeed, is as it should be: everything is converted into sugar that can be; and it is only the remnant that ought to find its way into the distil-house, for conversion into rum.

I have not hitherto remarked on a point that is of extreme importance in the distil-house—this is cleanliness! Cleanliness is particularly required in every department, from the mill-house to the rum-store: it is of as much importance in the distil-house, as in the milling, boiling, and curing departments; and the planter who aims at perfect success in distillation, must be nice and clean even to a fault. Every vessel should be constantly washed and scrubbed, and also well limed down, to prevent acidity; and by these means the distil-house, and everything that is in it, should always be perfectly sweet and clean.

We now leave the operations in the fermenting department, and enter on the distillation of the fermented wash. The apparatus used in separating the alcohol from the wash, is generally called a still; but the descriptions of still have so multiplied of late years, that some 300 or 400 patents might be mentioned, if it were of any utility doing so. I will, however, confine myself to a notice of those I have already named.

The first, which is one of the earliest improved stills, is that invented by Corty, and afterwards much simplified by Messrs. Shears & Sons, who term it "The Patent Simplified Distilling Apparatus."

Plate XVIII. is a representation of this still: A being the body of the still into which the wash is put; B is the still-head; C, C, C, are three plates of copper, fitted into the upper part of the boxes D, D, D; which are kept at a regulated temperature by water being conducted over their outer surface, by means of the pipe E, and the distributing pipes G, G, G. The spirit vapour then, rising from the body of the still, meets a check at the lowest plate C, by reason of the coolness occasioned by the water; this condenses the grosser part of the vapour and throws it back, whilst the lighter proceed on to the second plate C; where a further coolness condenses another portion of the vapour, leaving a much purer spirit to encounter the increased coolness at the third plate C. Here the last separation takes place; the aqueous and oleaginous particles, being unable to sustain the temperature maintained, fall back condensed, and only a very strong spirit passes over in the gooseneck. By means of the cock F, in the pipe E, the supply of water to the boxes D, can be very exactly regulated; and, as a natural consequence, the temperature can be very accurately adjusted.* *a*, is a screw cap through which a jet of steam or water may be sent, to clear away the deposit, which otherwise will more or less accumulate on the upper surfaces of the plates C. At the lower end of the worm-pipe is affixed, by means of the brass swivel joint screw H, a gas apparatus; which the Messrs. Shears consider a very important part of the improvement. The peculiar form of the pipe I, into which the spirit runs from the worm, causes it to be filled shortly after the still commences working; whilst the other branch pipe K, rises to some height, then returns and is immersed in the small box L, to the extent of about 2 inches in water. The gas from the still escapes by this pipe through the water; as the pressure can be but trifling.

It is held, that by means of this gas apparatus, the distillation proceeds in a partial vacuum, and that thereby there is a great economy in fuel. As the spirit enters the worm

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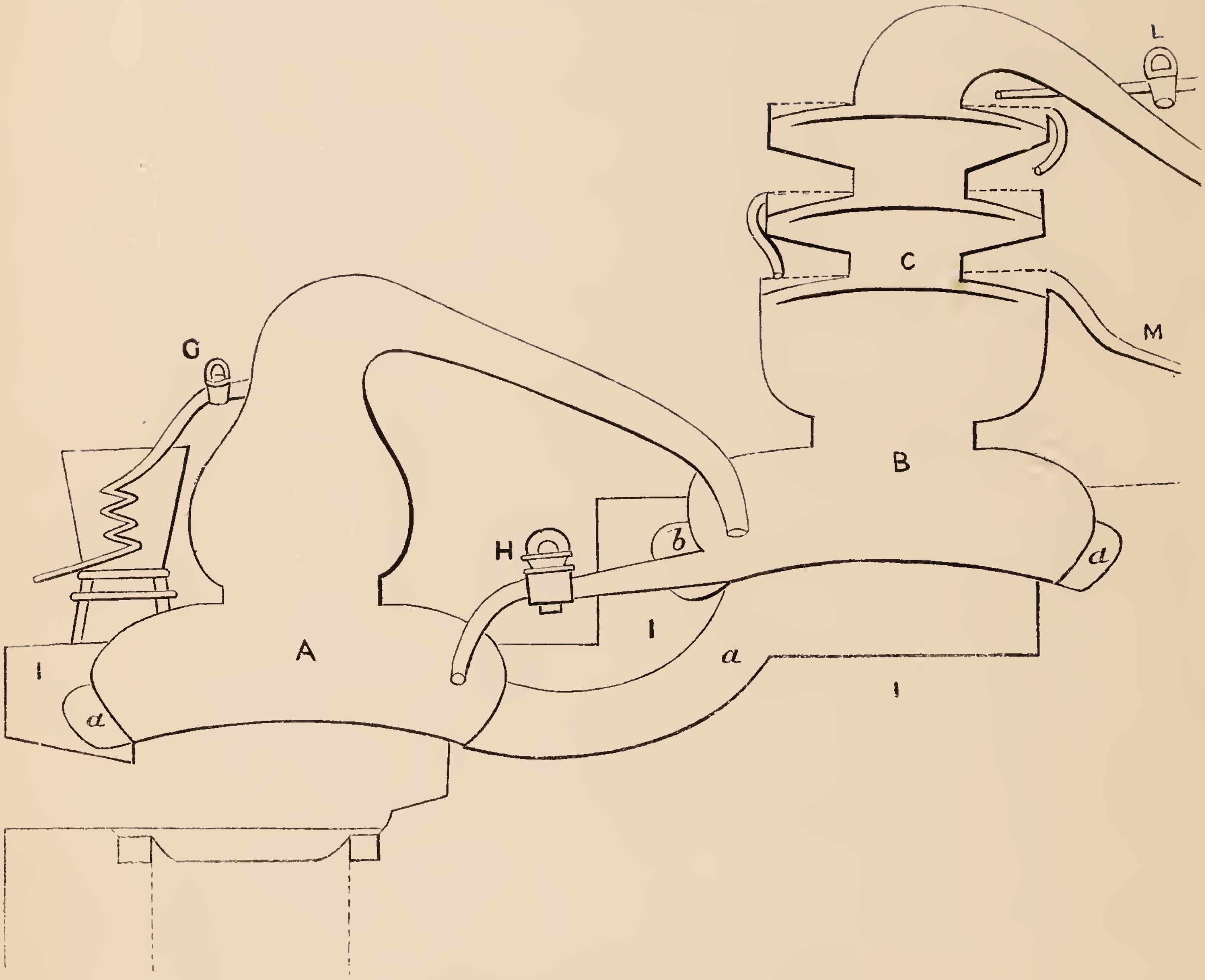
* If the temperature of the upper box be kept at 174°, for example, the alcoholic vapour which passes over will be comprised of 90 per cent. of pure alcohol, or 65 over proof; but with a temperature of 194° Fahr. the vapour will contain only 66 per cent. pure alcohol, or 30 per cent. over proof.



SHEARS' PATENT DOUBLE STILL.

at so much lower a temperature than in the old stills, that quantity of water is not required to cool the spirit vapour as would be otherwise.

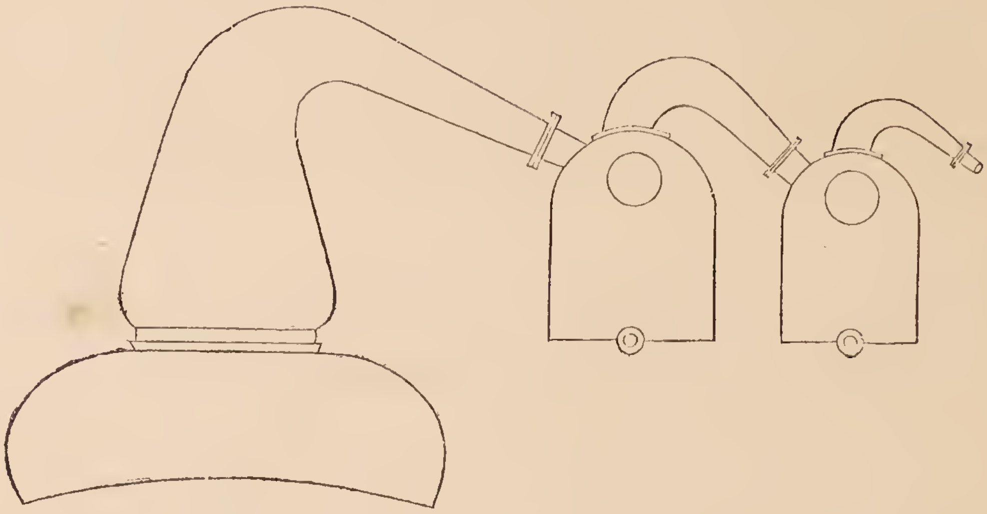
I have never worked with these stills myself; but I have seen many employed in the East, and always heard the best character given of them. One of 400 gallons is said to work off four to five charges in the day of twelve hours; yielding a spirit on an average of 35 per cent. over proof: which, for rum, is considered the most advantageous strength to run it at.

Plate XIX. is another arrangement of the same kind of still; being the addition of the common still A to the patent still B. In this case the contents of B are drawn down from time to time into A, and that of A run off as dunder; the spirit from A being conducted into B. One fire heats both stills; and it is stated that by the general adaptation and arrangement, a very large quantity of fine spirit is produced by the consumption of a very inconsiderable amount of fuel.

These double stills are in such repute that Messrs. Shears & Sons, have supplied, and are still supplying, numbers of them for the colonies: but particularly Demerara; where some of 1200 gallons are working to the entire satisfaction of their possessors.

The stills of Blumenthal, Laugier, and Coffey, though very excellent, and no doubt very efficient, are, notwithstanding, much better adapted for European distilleries than for sugar estates. I have seen many of them, as well as modifications of them, working on estates in India and the Straits; but I never knew them to afford satisfaction to their possessors: probably from not having such careful and skilful workmen to entrust them with, as are obtainable in Europe. From what I have already said, it will be seen that I entertain a very good opinion of the stills represented in Plates XVIII. and XIX., and consider them well adapted to the requirements of a sugar estate. But of all the different arrangements, I have never known any to surpass the common still and double retorts.

As a distilling apparatus peculiarly suited by its simplicity, durability, economy, and efficiency, to the wants of the planter, I considered that it stands unrivalled.



Common Still, with Double Retort, as manufactured by Shears' & Sons.

This represents the apparatus as it is commonly used; but, if provided with a wash-heater, the pipe from the second retort, instead of passing directly to the worm-tank, would first run through the charger containing the wash, impart to it a large portion of its heat, and then enter the worm-tank. A still of 1,000 gallons, so provided, should run off 500 gallons of rum, averaging 30 to 40 per cent. over proof, between five o'clock in the morning and eight o'clock P.M. In working the apparatus, the still itself is loaded with wash, and the two retorts with a few gallons of low-wines, or even water, sufficient to cover the bottom of the vapour-pipe: say about 15 or 20 gallons of low-wines in each.

The fire is then applied under the still, and rum of 40 to 45 over proof commences to flow into the can placed ready to receive it. When the still begins to boil, the loud rumbling of the retorts gives intimation of the fact, and warns the attendant distillermen to prepare for the spirit in the can-pit. The fire, if burning strongly, is slightly checked, clean cans are placed in readiness, and the superintendent stands by with his proof bubbles, or hydrometer, prepared to test the strength of the spirit. When it first begins to flow, a strong empyreumatic odour is perceptible; therefore the first gallon of spirit is thrown into the low-wine butt; then comes the strong, well flavoured rum, varying from 40 to 50 over proof.

If an average strength of 30 per cent. over proof, be required, the rum must continue to be thrown into the rum-butt, until the 20 bubble rises in the proof phial, when the remainder of the running must be thrown into the low wine butt; but if *proof* rum be wanted, the spirit may continue to be thrown into the rum-butt, until the 28 bubble rises, which will generally bring the whole running to 23: this, therefore, allows 2 bubbles for colouring, &c., to bring it to the 25 bubble or proof. In working with retorts I have found these rules to apply pretty nearly; but, to be quite sure, all that is requisite is, to test the contents of the rum-butt as the running progresses, by which no error can occur.

Whatever may be the description of distilling apparatus used, it is evident that the object of the planter must be to obtain from his fermented wash all the spirit it contains; and to do so as economically and expeditiously as he can: to accomplish this, I can, from long experience, strongly recommend the still and retorts.

The peculiar flavour of rum is generally understood to proceed from the resinous* aromatic gum (or essential oil), contained in the rind of the cane: but, apart from this, an empyreumatic oil appears to be generated during the fermentation of the wash, which Liebig ascribes to an interchange of the elements of sugar and gluten: from whatever source it be derived, however, all planters are quite aware how undesirable it is in rum, and at how much pains many are, to get rid of it, so as to improve the flavour of their rum. Its character may be judged of, from the fact that one drop is sufficient to taint ten gallons of spirit. Many are the expedients resorted to to expel this disagreeable taint; but amongst them all, I have found that charcoal and lime are the simplest and most efficacious: the former absorbs it, and the latter combines with it, and precipitates it in the form of soap.

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* Volatile or essential oil contained in plants is changed into resin by the absorption of oxygen (see Liebig).

The method I have employed myself, and known others resort to successfully, is to have a wooden box (of about 2 ft. long and 1 ft. in diameter, with a division in the centre running down to within an inch of the bottom), filled with coarsely-powdered charcoal, through which the spirit is made to pass as it runs from the worm in the can-pit: the charcoal absorbs a considerable portion of the oil, and the rum consequently flows from the filter much purified. It is then conveyed to the rum-butt (of about 300 or 500 gals.) which is situated at a good elevation, and at once treated with a little caustic lime (quick lime); being thoroughly stirred up to disseminate the lime. After an interval of two days, the flavour may be tried; and, if found satisfactory, the contents of the butt may be drawn off through a charcoal filter, similar to the first, into the colouring butt, to be coloured. But if the lime used be not enough, a little more must be added, mixing the whole up again; and after two days it may be run off as noticed. At this period the lime will be seen at the bottom of the butt, in combination with the oil; together forming a kind of soapy precipitate.

By carefully pursuing this plan, I have known rum of a month old, sell as two or three year old rum; so great a difference had it occasioned, and so much improved had the rum become in flavour.

It is, however, essential to remark, that both care and judgment are required in submitting the rum to this process; as too much lime will serve to render it a neutral spirit, altogether free from the well-known flavour of rum. But it is impossible to go wrong, if the operator will only pay the most ordinary attention to what he is about. I cannot too strongly urge on planters the expediency of using all means in their power to improve their rum as well as their sugar.

The next point is, to colour the rum which has been made and improved as above: and the art of making colour, I think, is one of the most important parts of the distillerman's business. It very frequently occurs that really good rum is quite spoiled by being badly coloured: this, therefore, should be strictly attended to.

The description of sugar that may be used for boiling colour, is a well-grained, fair-coloured Muscovado; such as is commonly chosen in Jamaica. This is put into a large copper or iron boiling pan, to which heat is applied; one man stands by with a wooden oar, or staff, and stirs it about continually, from the moment it begins to dissolve until the boiling is completed. Another man makes the fire; which may be of cane-trash, or dry brush-wood, so as to be instantly checked at will. As the boiling proceeds, bubbles rise, large and heavy at first, then small and quickly; the colour of the mass changes from brown to a deep black; the wooden stirrer shows the colour increasing to the desired shade, and the taste of the operator distinguishes the particular flavour required.

The nicety of his taste in a great measure decides the success, not only of the boiling, but of the subsequent flavour his rum will have. No sweetness whatever should be apparent, nor should there be any bitterness, but just the exact and happy medium.

Arrived at this stage, the fire should be drawn, and some strong proof rum be gradually added; the man stirring with might and main, until sufficient has been given to ensure the colour from assuming a solid form, on cooling: the whole mass may then be emptied into "the colour cask" in the rum store. This cask is generally a small hogshead placed, end up, on a wooden horse two feet high, and has a plug-hole two or three inches from the bottom, to draw off its contents when wanted, without disturbing any matter which may have precipitated.

Good colour is as thick as it can be, without forming a solid mass, and is as clear and bright as possible; mixed with rum, it should at once give it a clear, rich tint, devoid of any haziness or muddiness: but to insure this, it had better be mixed in a pail with a quantity of rum, and then carefully strained, previous to being thrown into the rum-butt. Very good colour will not require more than three pints to colour a whole puncheon of 100 gallons; whilst bad colour will not incorporate freely, but precipitate, leaving the rum only slightly tinged.

From a most mistaken economy, some planters use molasses for making colour; preferring to spoil a whole puncheon of rum rather than use sixpence worth of good sugar in making colour for it. I have seen colour made from molasses, and found it such bad stuff, that I cannot imagine any perfectly sane person can persist in its use.

Colouring rum is the last stage through which it passes before it leaves the estate; it is then put into hogsheads or puncheons for sale, or shipment.

This brings me to the end of my subject. I have now, therefore, only to take leave of my brother planters and other readers, who have followed me through the foregoing pages, and favoured me with their attention.

I have endeavoured to make this a useful work to the planter: I have attempted to show him, in simple guise, the various influences which affect the cultivation of the cane-plant, and the manufacture of its juice into sugar and rum; and ventured to point out to him the errors that exist, and the means of remedying them. I should be sorry to think that anything I have remarked on, should hurt the feelings of any one: nothing can be further from my thoughts than such an intention. My desire is, to benefit "the planting interest" by my humble exertions, and I shall sincerely rejoice to find that I have happily succeeded.

APPENDIX.

NOTE 1.—(In reference to page 81.)

My long absence from the West Indies, and the extraordinary changes that have occurred during that time, render it very difficult for me to afford anything like a correct estimate of expenses depending on local circumstances; hence I have thought it preferable to give an account merely of those items, in which I cannot err, leaving it to the West India planter himself, to supply those details which can only be known to those on the spot. I have now beside me accounts of the sale of Jamaica estates, by which I find, that many have been sold for little or nothing, and at this moment I know of others whose proprietors would willingly part with them on almost any terms; it is by no means easy, therefore, to assign any correct sum at which estate's lands can be purchased by a capitalist, although it is quite certain that the average price is exceedingly low. The following will, however, assist the planter in calculating the probable cost of producing sugar on a West India estate:—

BLOCK.—(Furnished the Estate.)

16-inch cylinder (high pressure) steam engine and mill (extra rollers)	£1,250
2 ranges (5 each) of iron, improved evaporating pans, containing 3,000 gallons	200
3 iron clarifiers (of 500 gallons each), with fittings complete	90
1 copper precipitator, or second defecator, complete	45
2 filters, each containing 20 bags, at 6*l.* each	12
10 animal charcoal filters, filled with charcoal	25
Kneller's concentrating pan (improved), to contain 200 gallons, and perfectly complete, with air-pump	120
50 curing cases, lined with very thin tin or lead	75
250 gallon-still, two retorts and wash-heater, complete	200
55 good, strong, young cattle, at 10*l.* a head	550
Agricultural implements, from Ransomes and May	50
10 two-bullock carts, at 10*l.*	100
	£2,717

To this must be added cost of land; improvements in roads, buildings, &c.; erection of machinery; and many minor requisites which may be demanded by the condition of the estate.

Outline of Current Expenses.

Cultivation of 150 acres of cane land (see page 68)	£730
Manual labour of thirty men (extra) 300 days, at 2s. a day each	900
Manufacturing charges on 8,662 cwts. dry sugar, at 1s. 3d.	540
Ditto ditto on 6,785 gallons of rum	100
520 tons of good coal, landed in the island at 1*l.*	520
	£2,790
Add to this Manager's salary	300
Two Assistants' ditto	300
	£3,390

Return Produce.

At twenty-five tons of canes to the acre; juice at 10° Baume's Saccharometer, or eighteen per cent. sugar.—See page 385, Table.

8,662 cwts. of very white crystalline sugar, worth in the island at least 15s. per cwt.	£6,497
6,785 gallons of rum, 30 per cent. overproof, at 3s.	1,017
	£7,514
Deduct as above	3,390
Balance	£4,124

This shows a balance of 4,124*l.*, wherefrom, items not placed, are to be deducted, after which a *profit* will most certainly be discovered!!

NOTE 2.

TABLE REPRESENTING THE SPECIFIC GRAVITY OF SOLUTIONS OF SUGAR OF VARIOUS STRENGTHS.

Specific gravity.	Sugar in 100 parts.	Specific gravity.	Sugar in 100 parts.	Specific gravity.	Sugar in 100 parts.	Specific gravity.	Sugar in 100 parts.	Specific gravity.	Sugar in 100 parts.
1000	·00	1057	·14	1118	·28	1187	·42	1263	·56
1004	·01	1062	·15	1123	·29	1193	·43	1268	·57
1008	·02	1066	·16	1128	·30	1199	·44	1273	·58
1012	·03	1069	·17	1133	·31	1204	·45	1279	·59
1016	·04	1073	·18	1137	·32	1209	·46	1284	·60
1020	·05	1077	·19	1142	·33	1215	·47	1289	·61
1024	·06	1081	·20	1147	·34	1220	·48	1295	·62
1028	·07	1085	·21	1152	·35	1225	·49	1301	·63
1032	·08	1090	·22	1157	·36	1230	·50	1307	·64
1036	·09	1095	·23	1162	·37	1235	·51	1312	·65
1040	·10	1100	·24	1167	·38	1241	·52	1317	·66
1045	·11	1104	·25	1172	·39	1246	·53	1321	·666
1049	·12	1109	·26	1177	·40	1252	·54		
1053	·13	1113	·27	1182	·41	1257	·55		

TABLE OF THE DENSITY OF SOLUTIONS OF SUGAR ACCORDING TO THE SCALE OF BEAUME.

Degrees of density.	Sugar in 100 parts.	Degrees of density.	Sugar in 100 parts.	Degrees of density.	Sugar in 100 parts.	Degrees of density.	Sugar in 100 parts.	Degrees of density.	Sugar in 100 parts.
1	·018	8	·144	15	·276	22	·406	29	·541
2	·035	9	·163	16	·294	23	·424	30	·560
3	·052	10	·182	17	·315	24	·443	31	·580
4	·070	11	·200	18	·334	25	·462	32	·601
5	·087	12	·218	19	·352	26	·481	33	·622
6	·104	13	·237	20	·370	27	·500	34	·644
7	·124	14	·256	21	·388	28	·521	35	·666

NOTE 3.

CORRESPONDENCE BETWEEN SPECIFIC GRAVITY AND PER CENTS. OVER PROOF AT 60°.

Proportion, by weight, of Alcohol and Water.		Specific gravity at 60°.	Per cent. over or under proof.	Absolute alcohol by weight in 100 parts.	Remarks.
Spirit.	Water.				
100	2·2	8298	60	87·0	The temperature in the Colonies being much greater than 60° Fahr. the proof bubbles should be regulated accordingly —60° being the standard.
..	6·9	8396	55	83·2	
..	11·6	8484	50	79·5	
..	17·1	8566	45	76·4	
..	21·8	8646	40	73·0	
..	27·5	8723	35	69·2	
..	33·4	8797	30 Over.	66·7	
..	39·7	8869	25	63·5	
..	46·7	8939	20	60·6	
..	54·3	9008	15	57·7	
..	62·7	9075	10	54·5	
..	71·3	9137	5	51·9	
..	81·2	9200	Proof.	49 0	
..	91·9	9259	5	46·3	
91·2	100	9318	10	43·4	
85·0	..	9374	15	40·8	
75·5	..	9426	20	38·3	
67·0	..	9475	25	35·6	
59·9	..	9521	30	33·0	
52·6	..	9564	35	30·5	
46·5	..	9602	40 Under.	28·1	
40·8	..	9638	45	25·8	
35·6	..	9671	50	23·3	
30·7	..	9702	55	21·0	
26·3	..	9732	60	18·5	
22·3	..	9760	65	16·1	
18·5	..	9789	70	13·8	

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